OCT 26 1923

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

To American Industry

The Secretary of War emphasizes the fact that the United States is making determined efforts to remove possible causes for war and to lighten burdens of preparedness. The system of national defense now adopted requires only a small standing army but demands the fullest possible coöperation of American industry in the mobilization of its resources. The leading article in this issue by the Chief of Ordnance calls for the serious consideration of all connected with the industries of the nation.

NOVEMBER 1923

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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J. A. Switzer

Selby Haar

R. H. Lowndes

C. C. Williams

J. W. Roe

W. R. Woolrich

Contributors to This Issue

Major General C. C. Williams, Chief of the Ordnance Department of the U. S. Army, contributes a paper on Ordnance Industrial Mobilization. General Williams was born in 1869 in Nacockee Valley, Ga. He was graduated from the U. S. Military Academy in 1894 and commissioned a second lieutenant in the artillery. In 1898 he was advanced to the rank of first lieutenant of Ordnance and in 1902 to that of captain, then serving for two years as assistant to the chief of Ordnance. From 1907 to 1912 he was a member of the joint Army and Navy Board to formulate specifications for steel forgings. For the next two years he was assistant to the commanding officer at Watertown Arsenal, Mass., and in 1914 was detailed as military observer with the German Army. In 1915 he was commissioned lieutenant colonel in the Ordnance Department and during the following year served on several important boards.

In May, 1917, he was ordered to France as Chief Ordnance Officer of the A.E.F., and in August of that year was commissioned Brigadier General, Ordnance Department, National Army. He returned to Washington in May, 1918, and was acting Chief of Ordnance until July when he was commissioned Major General, Chief of Ordnance. In 1919 General Williams was awarded the Distinguished Service Medal and the decoration of an Officer of the Legion of Honor, France. He was also made a companion of the Order of St. Michael and St. George, Great Britain.

* * * * *

Joseph W. Roe, whose paper on The Measurement of Management is included in this issue, is professor and head of the department of industrial engineering, New York University. Professor Roe was graduated from Sheffield Scientific School, Yale University, in 1895. From that time until 1906 he held respectively the positions of draftsman, chief draftsman, assistant superintendent, designer and engineer with the Winchester Repeating Arms Co., Henry R. Worthington, J. H. Williams & Co., and the Crane Co., when he became instructor and assistant professor in the mechanical engineering department of Sheffield. During the War he served as captain and later as major in the Air Service of the Army. In 1919 he became secretary of the Railway Car Manufacturers' Association and the following year executive engineer of the Pierce-Arrow Motor Car Co., Buffalo, N. Y. In 1921 he became associated with New York University. Professor Roe is president of the Society of Industrial Engineers, chairman of the meetings committee of the A.S.M.E., and a member of the executive board of the American Engineering Council.

* * * * *

J. A. Switzer and W. R. Woolrich, both of whom are on the faculty of the University of Tennessee, are co-authors of the paper on The Water, Coal and Man Power of the Western Slope of the Southern Appalachain Mountains. Professor Switzer was born in 1871 in Brooklyn, N. Y. He was graduated from Cornell University in 1896 with the degree of M.E in E.E. He has taught in the University of Pennsylvania and the Northern Illinois State Normal School. Professor Switzer has had a wide experience in railway construction, irrigation, and sanitary and hydroelectric engineering. Since 1908 he has held the chair of hydraulic and sanitary engineering in the University of Tennessee, also working as a consulting engineer along those same lines.

Professor Woolrich was graduated from the University of Wisconsin in 1911. He completed the student-training course in the Western Electric Co., Chicago, and was assigned to the Deering Works of the Harvester Co. to organize a training course for apprentices. In 1916 he became assistant professor at the University of Tennessee and organized the course in factory management. Three years later he entered into a consulting engineering partnership with W. E. Biggs, while still continuing his relationship with the university but as associate professor of mechanical engineering.

* * * * *

The article on the Chemical Warfare Service published in this issue is based on information supplied to a member of the editorial staff of Mechanical Engineering by the engineers and chemists of the Chemical Warfare Service, War Department, Edgewood Arsenal, Md. The article also includes brief description of apparatus for air analysis which has been contributed by a member of the Edgewood Arsenal staff, Dr. T. B. Hine, Chief, Physical Department, Chemical Division.

* * * * *

Selby Haar, assistant electrical engineer with the Transit Commission of the State of New York and in charge of the engineering section of the Bureau of Equipment and Operation, writes on Modern Subway Cars and Their Operation. Mr. Haar was born in Kansas City, Mo., in 1881. He was graduated in 1904 from the Massachusetts Institute of Technology as an electrical engineer. He completed the testing course of the General Electric Co., Schenectady, N. Y., and then engaged in engineering inspection and design with manufacturing companies, public utilities and railroads. Mr. Haar has been connected with the Transit Commission and its predecessors since 1916.

* * * * *

R. H. Lowndes, author of the article on The Use of Pulverized Coal in Open-Hearth Furnaces, is chief engineer of the Atlantic Steel Co., Atlanta, Ga. Mr. Lowndes was born in South Carolina. He is a graduate of the Georgia School of Technology, class of 1903. For a short period he was with the Telephone Co. in Atlanta and then did some independent mill work, installing machinery. Later he taught for seven years at Georgia Tech. During the War Mr. Lowndes was in charge of the civilian work of a U. S. Army Training School. Afterward he again entered the consulting field where he was engaged until 1921, when he became associated with the Atlantic Steel Co.

A.S.M.E. Annual Meeting, December 3-6

The development of hydroelectric power will be the subject of the leading session at the coming A.S.M.E. Annual Meeting, and the A.S.C.E. and A.I.E.E. are to coöperate in the program for this season. Numerous other sessions have been arranged which will be under the auspices of the Textile, Management, Gas Power, Power, Fuels, Railroad, Ordnance, Aeronautic and Machine-Shop Practice Divisions. The National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace during the same week.

The final program with announcement of papers and authors will be made in the A.S.M.E. News for November 7.

MECHANICAL ENGINEERING

Volume 45 November, 1923 No. 11

Ordnance Industrial Mobilization

Under the Supervision of the Assistant Secretary of War

By MAJOR GENERAL C. C. WILLIAMS,[1] WASHINGTON, D. C.

BATTLES and wars are won or lost by *men*. This has been so ever since man first appeared upon the earth, and will continue to be the case until civilization is able to evolve a form of organization which does away with war as a means of settling international disputes.

Weapons used by men are but tools. The nation armed with inferior weapons may be hopelessly handicapped, or a preponderance of numbers may make up for the inferiority if it is not too great. But war is a partizan matter. Our duty is not to prepare for war as a game in which uncertainty of victory will add interest and zest to the conflict. It is to insure that, if war unfortunately comes, the United States will be able to make the most effective use of her resources with the object of securing a successful peace as quickly as practicable. It is axiomatic that our forces should be assured a supply of war matériel *at the minimum equal in quality and amount to that available to a probable enemy.*

DWIGHT F. DAVIS—ASSISTANT SECRETARY OF WAR

As Assistant Secretary of War, Mr. Davis is charged with supervision of the procurement of all military supplies and the assurance of adequate provision for the mobilization of industrial organizations essential to war-time needs.

NATURE OF MODERN WAR

Our early ancestors doubtless settled their differences with weapons found at hand. Stones and clubs were readily accessible and there were no questions of "war reserves" and "military procurement." It would be interesting but beside the point to trace the gradual evolution of the military art from its prehistoric beginnings to the present time as influenced by the increasing complexity of available weapons. Suffice it to point out that military art has always been quick to take advantage of every discovery and advance in science and engineering. Conversely, military needs have very frequently forced developments of reciprocal advantage to peace-time pursuits. To wage war effectively today requires the use of enormous quantities of highly complex material. To furnish this material a correspondingly highly organized industrial effort is necessary. Major military efforts now involve not only the military forces of a nation—its army and navy—but require the active coöperation of its entire population and of all its industry.

More than ever before, war is an economic problem. The question confronting a nation at war is so to distribute its population and available resources that the war may be most effectively waged and with as little disturbance to the economic life of the country as practicable.

This involves the following main considerations:

1 A decision as to the proportion of the citizenry to be called to the colors and organized as military and naval forces; in short, a military program;

2 Arrangements for providing these forces with food, clothing, and medical care and otherwise supplying their requirements for existence as human beings in a strange environment under severe physical and mental stress;

3 Equipping the fighting forces with the special instruments of warfare—guns, ammunition, tanks, airplanes, gas masks, fire-control equipment, and the multitudinous other special articles which are required in the scientific warfare of today;

4 Maintaining the non-military life and activities of the country during the war as well as circumstances permit.

The first of the above considerations is, for the United States, a matter for decision in the primary instance by the Commander-in-Chief, the President, subject of course to confirmation by Congress, in the form of laws and funds for its support. Naturally a decision of such grave import is never reached without a most careful consideration of all phases of the situation, military, diplomatic, and economic. It is mentioned here because of its double effect on munitions production, i.e., the greater the number of men called to the colors, the *greater* the quantity of arms and ammunition required and the *less* the available working population to produce the requirements. Obviously there must be some proportion between the total population and the total number of the troops mobilized which is best for a particular country under a particular set of conditions.

The second of the considerations named above requires little comment. The individuals who compose an army would likewise require food, clothing, and medical attendance were they civilians. Agencies for furnishing these services exist in time of peace. The main difference in time of war is that inevitably there are increased demands, increased wastage, and poorer facilities for distribution. The ordinary trade channels are to a greater or less extent disorganized, and new machinery must be set up for the supply. Clothing for military use, for instance, will be of a different dye and of military cut. It will be distributed by issue and not through trade channels. All this makes the problem most difficult, but the point which it is desired to make here is that what is required is a diversion and, in many cases, an expansion of facilities already in existence for supplying the peace-time requirements, rather than the establishment of new facilities and the creation of new industries.

Passing over the third consideration for the moment to the fourth, it is obvious that the non-military life and activities of a country must be carried on in war measurably as in peace. Food, shelter, clothing, etc., are as necessary to the civilian population as in peace.

[1] Chief of Ordnance, U. S. Army.

GREETINGS TO THE MEN IN THE INDUSTRIES OF THE UNITED STATES BY THE HONORABLE, THE SECRETARY OF WAR, JOHN W. WEEKS.

No country has made nor is making more determined efforts than ours to remove possible causes for war and to lighten burdens of preparedness.

We now have a system of national defense which enables us to maintain the smallest regular army, in proportion to population, not only among the great powers of Europe but also among the countries of our own continent, excluding Canada, which is protected by its participation in the British Empire.

The essential parts of our new system cannot be neglected.

The National Defense Act of Congress, June 4, 1920, requires the "assurance of adequate provision for the mobilization of materiel and industrial organizations essential to war-time needs."

It is the greatest satisfaction to me to find that the Assistant Secretary of War, who is directing this whole movement, has the patriotic support of the professional men, engineers, manufacturers, and business men of the country.

The accompanying article by the Chief of Ordnance calls for the most serious consideration of all connected with the industries of the Nation.

JOHN W. WEEKS,
Secretary of War.

There will be many changes and curtailments, but the industrial morale is as indispensable to success as that of the fighting men. The "army back of the army" is just as essential to winning a war as the army proper. Then, too, some regard should be paid to the fact that every war must eventually end and that transition from war to peace is in many ways more difficult than that from peace to war. Sight of this fact tends to become lost in time of war. The main thing is, of course, to win the war, and all other things must be subordinated to this.

INDUSTRIAL PREPAREDNESS

Returning to the third consideration mentioned, the primary object of this paper is to discuss the means which are being adopted in time of peace in order that our army may have an adequate supply in time of war of the special instrumentalities of war known collectively as "ordnance."

While man power usually is the deciding factor in war, the tremendous growth in quantity and complexity of war matériel has rendered the supply of this matériel the limiting factor in developing the military effort of our nation—in making our man power effective. Men can be mobilized and trained much more rapidly than they can be provided with munitions of war from new production. It is generally admitted by those who have studied the problem that, on the average, no appreciable quantity of munitions from new production can be delivered to the troops during the first year of a modern war. In other words, the early stages of a war must be fought from reserves accumulated during peace and on hand when war breaks out.

Of course, the supply of instruments of warfare which have no peace-time counterparts is not confined entirely to the Ordnance Deparment. Other supply services, notably the Air Service and the Chemical Warfare Service, likewise have such supply problems. However, the great bulk of such supply for our Army, perhaps ninety per cent of it, falls on the Army Ordnance Department, and the basic method of solution is the same for all services. I shall cover only the question of procurement proper. The equally important problem of distributing the matériel to the army after it has been procured is not here discussed. The importance of the subject lies in the fact, already pointed out, that the supply of munitions is the controlling factor limiting the speed of mobilization.

The procurement activities of the several supply services of the War Department are supervised and coördinated by the Assistant Secretary of War. The duties of the Assistant Secretary in this connection are prescribed by the National Defense Act, as amended on June 4, 1920, as follows:

> Hereafter, in addition to such other duties as may be assigned him by the Secretary of War, the Assistant Secretary of War, under the direction of the Secretary of War, shall be charged with supervision of the procurement of all military supplies and other business of the War Department pertaining thereto and the assurance of adequate provision for the mobilization of matériel and industrial organizations essential to war-time needs.

This simple provision is undoubtedly the most important and far-reaching change in the military policy of the United States since the formation of the General Staff in 1901.

ANALYSIS OF THE PROBLEM

The first step is necessarily a determination of what is required, in what amounts, and at what times. This depends upon the man power which is to be mobilized and certain factors which are laid down by the War Department. The basic source is the "General Mobilization Plan" of the War Department General Staff, which has the formal approval of the Secretary of War and covers the troops proposed to be used by the United States in the event that it is called upon to exert its "maximum effort." This document is highly confidential. It answers the first of the considerations enumerated above as far as this can be done in time of peace. The organization of these troops is covered by "Tables of Organization," and their equipment by "Tables of Basic Allowances."

If, for example, we wish to know the amounts of 75-mm. high-explosive shell which should be provided for, we can determine from the above sources the number of guns which will probably be consuming these shell in action and in training, month by month, after the emergency arrives. Then, from officially established "Rates of Fire" we can determine the consumptive requirements of the troops for these shell. By making suitable allowances for the time consumed in transporting the matériel to the front, we obtain data as to the amounts which must be delivered from the factories or depots month by month. This may be shown graphically as in Fig. 1. (The data used in this figure and elsewhere in this paper are assumed for the purpose of illustrating the methods and bear no relation to our actual war plans.)

When similar computations have been made for each item of supply, our industrial requirements are definitely known. About 1200 articles of issue are supplied by the Ordnance Department. These embrace about 250,000 components. Knowing our total requirements, the next question which presents itself is, "How are we going to get them?"

MANUFACTURING ARSENALS

The Ordnance Department has six large manufacturing arsenals, namely, Watertown, Frankford, Rock Island, Picatinny, Springfield Armory, and Watervliet, and these are the sources of supply most readily available. They are continuously working at re-

PRESIDENT HARRINGTON PROCLAIMS COÖPERATION OF A.S.M.E. IN INDUSTRIAL-PREPAREDNESS PLAN

The plan of the War Department to keep the nation fit and ready will have the heartiest coöperation of The American Society of Mechanical Engineers. A large standing army provides the means for instant action, tends to make a nation quick to anger and arrogant and aggressive in its relations with others, just as carrying a gun tends to make the individual act violently and without deliberation; but the organization of industry and the making ready of needed plants and of the men responsible for their operation provide the essential industrial support for the more readily organized fighting units and give the nation the calm assurance of strength which makes for deliberation and peace while it discourages aggression on the part of others. The plan of avoiding the belligerent attitude and the economic waste of men and means involved in a standing army, while keeping fit to meet effectively any emergency, is sound and in full accord with American ideals; therefore it merits and has the unreserved patriotic support of our Society and of its individual members.

JOHN LYLE HARRINGTON, President,
The American Society of Mechanical Engineers.

duced strength and can be brought to maximum capacity promptly when the need arises. Their total capacity, however, is relatively small compared with the total requirements under a maximum-effort program. They would be able to produce less than 10 per cent of the required ordnance matériel. Their principal mission is to keep alive in time of peace a knowledge of the art of making ordnance which would otherwise practically vanish. This is a very important function and its value to the United States is incalculable, but the arsenals cannot be depended upon to carry any great portion of the war load.

THE DISTRICT SYSTEM

The real answer to the question, "How are we going to get them?" lies in the Ordnance District System. Under this system the United States has been subdivided into fourteen Ordnance Districts, as shown in Fig. 2. The object in setting up these districts is to secure decentralized procurement. That such decentralization is essential was shown during the World War. In fact, the districts were first set up by the Ordnance Department during that war and the new arrangement differs from the old chiefly in that the districts are now given greater responsibility and power than before. They are now set up as skeleton organizations to be expanded promptly, in event of need, to full strength.

Each district is in charge of a "district chief." These chiefs have been chosen from among the prominent men of their respective districts. They are men of large affairs who have the support and respect of industry in their districts. While in time of peace it is expected that district chiefs will supervise rather than go into the details of the work, many of them devote a surprisingly large proportion of their time to the affairs of the district. In time of war they would devote their entire time to district activities.

Each district chief has assigned to him in time of peace, as executive assistant, an officer of the regular army, whose entire time is devoted to the work.

The duties of the district offices in time of war will be to procure, produce, and inspect such quantities of ordnance matériel as may be assigned to their respective districts, and each district chief is supreme in his district as far as these functions are concerned. In time of peace they prepare for this work in the manner discussed below.

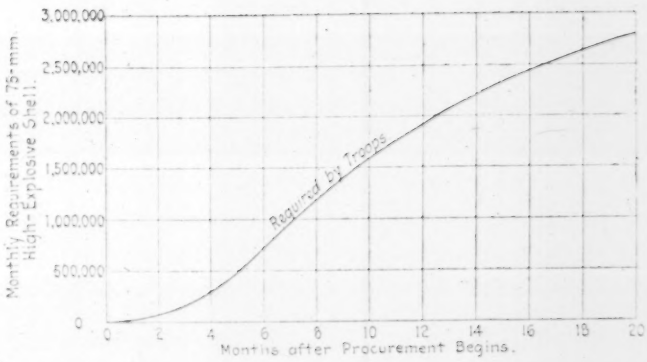

FIG. 1 CHART SHOWING AMOUNTS OF 75-MM. HIGH-EXPLOSIVE SHELL WHICH MUST BE DELIVERED FROM THE FACTORIES OR DEPOTS MONTH BY MONTH

The following is a list of district chiefs appointed to date:

District	*Chief*
Baltimore	HOWARD BRUCE
Birmingham	COL. C. L. HARRISON
Boston	COL. C. H. TENNEY
Bridgeport	COL. B. A. FRANKLIN
Chicago	E. A. RUSSELL
Cincinnati	COL. C. L. HARRISON
Cleveland	COL. BASCOM LITTLE
Detroit	H. A. O'DELL
New York	COL. JOHN ROSS DELAFIELD
Philadelphia	JOHN C. JONES
Pittsburgh	R. M. DRAVO
St. Louis	M. E. SINGLETON
San Francisco	LT. COL. BRUCE CORNWALL

The war organization of the Manufacturing Service of the Ordnance Department and the District Offices is shown in Fig. 3. It is to be noted that for each division of the Manufacturing Service

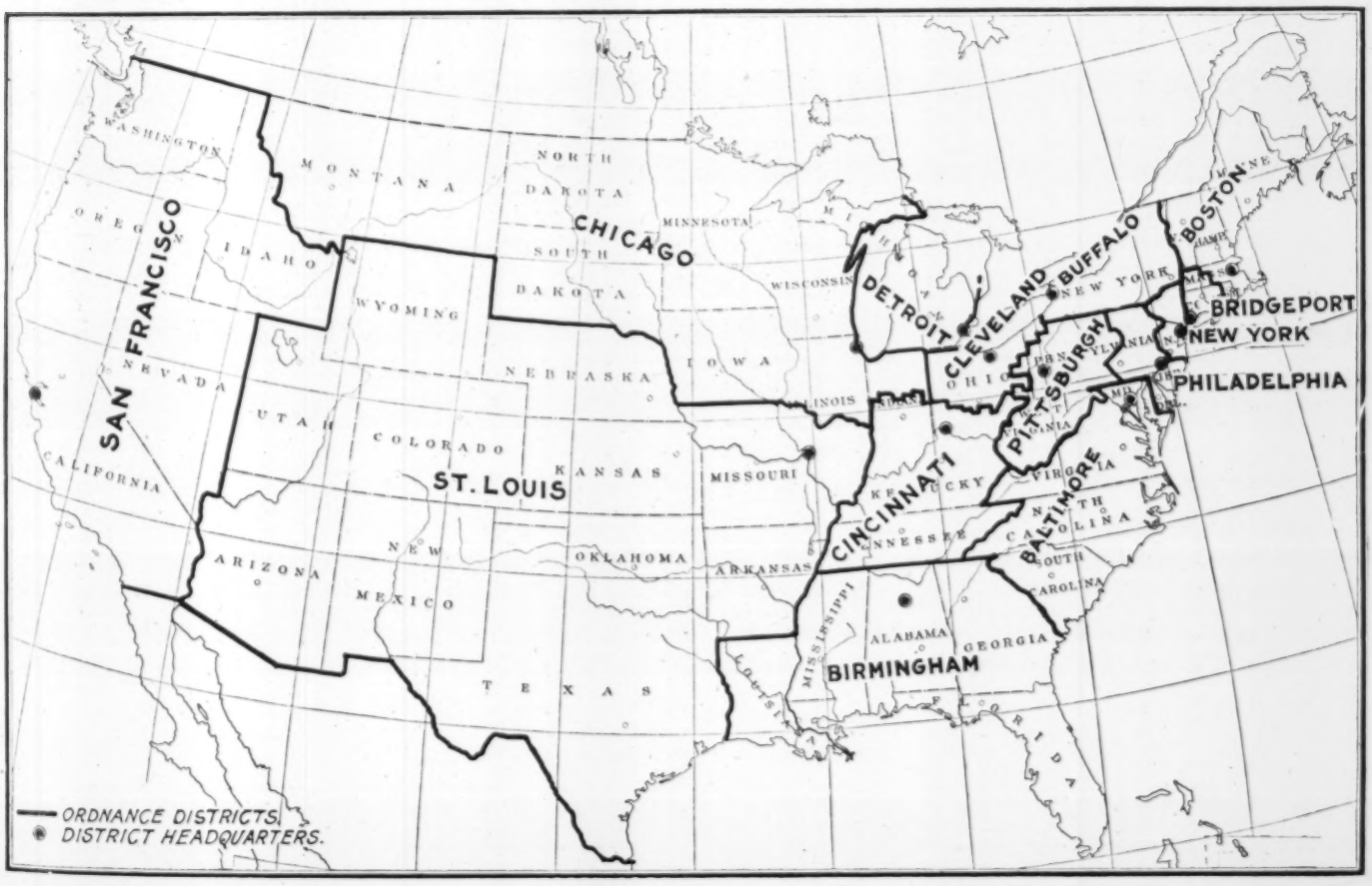

FIG. 2 MAP SHOWING THE FOURTEEN ORDNANCE DISTRICTS INTO WHICH THE UNITED STATES IS DIVIDED

there is a corresponding division in the District Offices. These divisions are further divided into sections. For instance, the Artillery Division of the Manufacturing Service and the Artillery Divisions of the several District Offices include the following sections:

Cannon Section
Fire-Control Section
Mobile-Gun Section
Railway and Seacoast Section.

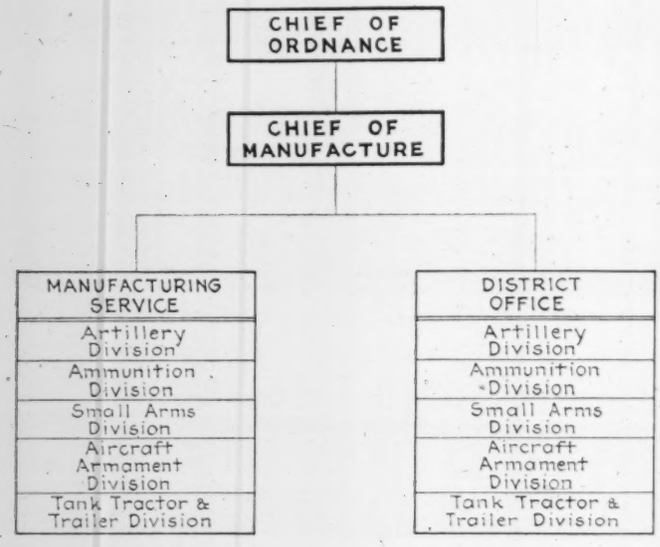

FIG. 3 WAR ORGANIZATION OF THE MANUFACTURING SERVICE OF THE ORDNANCE DEPARTMENT AND THE DISTRICT OFFICES

The object of this parallel organization is to facilitate the transaction of business. A very large portion of all communications between the Ordnance Office and the districts in time of war will involve routine matters or be concerned with minor decisions only and will go direct from the heads of corresponding sections. Only cases involving policy or differences of opinion which cannot be settled in this manner will be referred higher. For instance, a difficulty which the cannon section of the Ordnance Office cannot settle with the cannon section of a particular district may be settled by the heads of the respective artillery divisions, or it may be referred still higher and be decided by the chief of the Manufacturing Service. This official is the first in the chain who has direct *control* over the entire organization. The lines of communication between the sections and divisions are chiefly informative.

ALLOCATION OF ORDERS

The total requirements for matériel for which the Ordnance Department is responsible having been worked out as indicated above, the next step is to place war orders for the matériel. These orders are being placed at the present time. They will be revised yearly in time of peace and, of course, will be modified continually in time of war. The process of placing them is as follows:

The total requirements for a given article, as for instance the 75-mm. high-explosive shell, are divided between the districts as well as can be determined from existing knowledge of the capacities of the several districts. The amount of each article which it is desired to get from each district is then allocated to that district on the form shown in Fig. 4. This gives complete information as to what is wanted from the districts. The district office investigates the various firms in the district which may be in a position to produce the article and decides upon which are to be given orders for it. These orders are reported to the Ordnance Office on the forms shown in Fig. 5. Any necessary correspondence in relation to placing orders for matériel is conducted directly with the proper division of the Ordnance Office. The sum total of all orders for a given article can, of course, be known from these reports. This will represent the capacity of the country which is to be placed in production for this article in the event of a major emergency.

In order to prevent conflict between the several procuring services, the Assistant Secretary of War allocates the various industrial organizations which may be in a position to accept war orders, in such manner as the best interests of the Government seem to dictate. In this way endless confusion and duplication of effort are prevented and each organization understands exactly what the total demands of the War Department upon it are to be.

RESERVES

Requirements are computed on the basis of the needs of the army month by month. The maximum requirements for items which are consumed, such as ammunition, are reached when the army has reached its maximum strength and is completely engaged in the theater of operations. The total production to be reached in the districts is planned accordingly. Naturally, it will take a considerable period for the factories to reach this production. Since troops can be trained more rapidly than munitions can be gotten into production, and it is essential that sufficient troops provided with necessary munitions be available at all times to prevent defeat before the industry of the country can assume its load, the available new production in the early months of the war will inevitably fall below the needs of the troops. A deficit will be incurred as illustrated by Fig. 6. To tide over the period during which new production is insufficient, sufficient reserves must be maintained in storage. From economic reasons these are kept to a minimum both in kind and amount. *However, the maintenance of a proper reserve behind which our industry may be mobilized is an indispensable element of the national defense.* In fact, considering the highly developed state of our manufacturing methods and our great natural resources, it seems fairly certain that no power or combination of powers now in existence could successfully invade the United States after our man power and our industry had been fully mobilized. From this point of view and from the standpoint of

CONFIDENTIAL

ORDNANCE WAR ORDER NO. 763

FOR 75 mm HIGH EXPLOSIVE SHELL (COMPLETE ROUNDS)
NAME OF ARTICLE

THE FOLLOWING QUANTITIES OF THE ABOVE NAMED ARTICLE ARE ALLOCATED FOR MANUFACTURE TO THE DETROIT DISTRICT IN THE EVENT OF A MAJOR EMERGENCY

UNIT 1,000 SHELL DATE June 3, 1923 REVISED

MONTHS AFTER PROCUREMENT BEGINS	QUANTITIES BILLED AND DELIVERED TO CARRIERS	MONTHS AFTER PROCUREMENT BEGINS	QUANTITIES BILLED AND DELIVERED TO CARRIERS
1		13	200
2		14	200
3	50	15	200
4	75	16	200
5	100	17	200
6	150	18	200
7	200	19	200
8	200	20	200
9	200	21	200
10	200	22	200
11	200	23	200
12	200	24	200

TOTAL QUANTITY COVERED BY THIS ORDER 3,975,000

REMARKS: Complete round consists of the following:

H.E.Shell, loaded,
Adapter & Booster, loaded
Fuze, loaded,
Base cover,
Cartridge Case,
Primer, loaded,
Packing Box,
Propelling Charge.

(Sgd.) John Smith
CHIEF Amm. DIVISION

ARTICLE 75 mm H.E. SHELL (COMPLETE ROUNDS)

FIG. 4 FORM USED IN ALLOCATING QUANTITIES OF AN ARTICLE TO A GIVEN DISTRICT FOR MANUFACTURE

the present economic development of the world, it may be said that *our next major war will be won or lost on the adequacy of our reserves.*

ECONOMY OF SYSTEM

The events of the World War are too fresh in our minds to make it necessary to emphasize the money savings that will result because of an orderly peace-time approach to the problem of placing war orders. There will be no excited competitive bidding for facilities between different branches of the Government; there will be no over-ordering of one article or component with consequent unbalancing of supply. Manufacturers will have opportunity to deal locally with representatives of the Government in time of peace and each will know what he is expected to produce in time of war.

CONFIDENTIAL

REPORT ON PRODUCTION SCHEDULE NO. 498

FOR 75 mm HIGH EXPLOSIVE SHELL (COMPLETE ROUNDS)
NAME OF ARTICLE

DETROIT ORDNANCE DISTRICT

UNIT 1,000 SHELL DATE Sept. 6, 1923 REVISION

MONTHS AFTER PROCUREMENT BEGINS	DESIGNATION OF PLANT OR FIRM WITH MONTHLY DELIVERIES TO CARRIERS			
	A	B	C	D
1				
2				
3				
4				
5				
6	20	25		
7	30	35		
8	40	50		
9	55	60		
10	70	75		
11	90	100		
12	100	100		
13	100	100		
14	100	100		
15	100	100		
16	100	100		
17	100	100		
18	100	100		
19	100	100		
20	100	100		
21	100	100		
22	100	100		
23	100	100		
24	100	100		

NAMES OF PLANTS OR FIRMS TO BE LISTED BELOW TO CORRESPOND TO LETTERED COLUMNS ABOVE. AFTER NAME OF EACH PLANT OR FIRM STATE WHETHER REFERENCE IS HAD TO THE USE OF "EXISTING FACILITIES," "READILY CONVERTIBLE FACILITIES" OR "NEW FACILITIES." USE TWO OR MORE SHEETS IN CASE MORE THAN FOUR PLANTS ARE REPORTED.

A THE BROWN MANUFACTURING COMPANY - New Facilities
B JONES & SMITH CORPORATION - New Facilities
C
D

ARTICLE 75 mm HIGH EXPLOSIVE SHELLS (COMPLETE ROUNDS)

FIG. 5 FORM USED BY DISTRICT OFFICE IN REPORTING TO ORDNANCE OFFICE THE ORDERS GIVEN FOR PRODUCTION

By proper planning the time interval between the beginning of war-procurement negotiations and the delivery of the munitions to the troops will be greatly reduced. Such a time reduction will shorten any modern war since a preponderance of munitions will hasten the end of the war. In money such a curtailment of hostilities may easily mean a saving of a vast amount. Thousands of lives on which a money value cannot be placed will also be preserved to the country.

The outlay in time of peace to secure this condition of preparedness is not excessive. The coöperation of the potential producers is the important consideration. A relatively small amount of cooperation from the many potential producers in this country is rapidly placing the United States in a state of industrial preparedness immeasurably better than ever before in the history of the country.

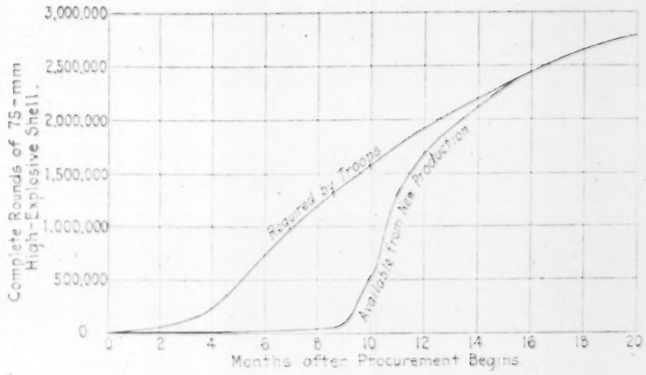

FIG. 6 CHART SHOWING INSUFFICIENCY OF NEW PRODUCTION OF SHELL FOR TROOP REQUIREMENTS AND THE NECESSITY OF MAINTAINING RESERVES IN THE EARLY MONTHS OF THE WAR

Conversion of Skoda Works to Peaceful Purposes

THE Skoda Works in what is now Czechoslovakia were justly called the Austrian Krupp's. Since the armistice they have been converted to peace-time production with apparently gratifying success both technically and commercially.

Where before and during the war the greatest shops of the company were bristling with long-range guns, dreadnought turrets, and other implements of war, today one sees only the construction and assembling of locomotives, newspaper presses, milk separators, and similar peaceful and productive work in hand.

From the standpoint of economics this fact in itself is a remarkable feat. Before the Treaty of Versailles, the Skoda Werke of Pilsen occupied a position in the dual monarchy not dissimilar to that of Krupp's in Germany. When the war came the Skoda plants were rapidly enlarged and together bore the burden of supplying the Austrian armies with the bulk of their artillery. When the war ended it seemed as if factories like Skoda would be forced to close up shop in part at least, or cast about for ways and means of adapting themselves to the changed conditions of the market.

Czechoslovakia, where the works are now located, is a comparatively small country and would not be capable of supporting such a large plant as the Skoda which had therefore to go into lines of production where they could count on a wider market. To do this they have bought patents, have experimented along new lines of manufacture, and carefully studied the demands of other countries. They began the manufacture of agricultural machinery, for which it was thought there would be a big market following the war, by buying from the Prager Works of Prague their patent on an 80-hp. heavy motor plow. Tractors and small plows, together with cream separators, were also added to the agricultural program. The war led to unusual depression in most of the factories of the warring countries, so that an increased demand for steam and gas engines and stationary boilers of all kinds was a foregone conclusion.

To replace mining equipment which had been allowed to deteriorate and provide machinery for mining on a wider scale, conveyors and ore separators were added to the list. A pronounced boom in shipping immediately following the war led to the production by the Skoda Works of steam turbines and marine engines for Italy.

Another more important line of development was found in the building of locomotives and railway equipment. No new types of locomotives were demanded, since the Czechoslovak Government, pending the development of electrically run railroads, preferred locomotives of a type which would afford easy interchangeability of parts with old engines which had been left to them under the treaty. Practically the only new type, in fact, which has been built by the Skoda Works since the war is an 83-ton locomotive with a 2–10–0 wheelbase.

In this connection, it should not be forgotten that the Skoda Works, even before 1914, occupied an important position in the industry, in fact a dominating one in certain lines. This was so to such an extent that, for example, the pipe bends installed in the giant turbines at Niagara Falls were turned out in the Skoda factory just before the war.—Henry Obermeyer and Arthur L. Greene in *American Machinist*, vol. 59, no. 14, Oct. 4, 1923, p. 519.

Measurement of Management

The Need of Measurement—Characteristics Necessary in Any Method of Measuring Management—Outline of a Method for Comparing Managerial Performance in Different Plants or Variations Thereof in a Single Plant

By JOSEPH W. ROE,[1] NEW YORK, N. Y.

THE purpose of this paper is to outline the problem and to suggest a method for evaluating management which will be trustworthy, practically useful, and as free as possible from the element of personal opinion.

Is Management Measurable? It is desirable to face this question squarely in view of the frequency with which we encounter one or the other of two answers to it. The first is, "Of course it is, and the balance sheet and profits are the measure." This is too easy to be true. Profits are usually an indication of good management, not a quantitative measure of it. They depend on conditions beyond the control of the management, as well as on those within its control. A business which showed a good profit in 1919, at the height of the boom, may have shown none in 1921, at the depth of the depression; and yet it may have called for more skill to have avoided a receivership in 1921 than to have earned the dividend in 1919. Any true measure must confine itself to those conditions over which management has control.

The other answer is, "No. Skill in management is too complex and too personal to be capable of measurement at all." This is the other extreme. Management must be, and is being, daily evaluated in *some* way, if not by measurement, then by personal judgment. The complexity and personal element are granted. Management, from this very complexity, is partly mechanistic, conforming to natural and sociological laws, and only in part personal. The terms "Science of Management" and "Art of Management" are both in general use. In so far as management is a science, measurement can and should be used, to the great advantage shown in every other science. Those elements which constitute an art, and are based on personal skill, leadership, and imagination, as well as the vital element of integrity, can and should be left to judgment as heretofore. Where applicable, measurement is more trustworthy. It should therefore be applied wherever possible.

What Does Management Cover? Management is recognized to cover a much wider field than formerly. This is reflected in the transactions of the A.S.M.E., which contain the most complete record of its development. The earlier volumes deal only with the technical aspects of production. In 1886 Mr. Towne proposed that the Society undertake to gather information on industrial management. In 1889 he gave his paper on Gain Sharing, and Mr. Halsey's paper on the Premium Plan was given in 1891. In later volumes one sees the range of topics constantly widening. Mr. Taylor's work was, at first, also directed toward finding a satisfactory basis for wage payment, but his investigation steadily broadened until it included a whole system of shop management, cost accounting, routing and scheduling, etc. Today management is generally recognized to include not only production, but finance, purchasing, sales, accounting, and personnel administration.

The methods of measurement proposed in this paper will be confined chiefly to the field of production, although it should be recognized from the start that production is only one of a number of equally important functions. This limitation is made because it seems at present to be the field in which measurement can be most readily applied and with the greatest promise of success. The development of a workable method covering production may make it easier to develop methods for other fields.

The Need of Measurement. The management function has been *judged* since the days of the stone age, when men first began to work collectively. Until recently, however, there has been little thought of actually *measuring* it.

There is a great difference between judgment and measurement. To judge is to arrive at a conclusion or a decision by weighing or comparison. To measure is to ascertain quality, dimensions, or quantity by comparison *with a standard*. In judging things, they are compared one with another. In measuring them, all are compared with the same thing, namely, the standard. Comparison is common to both, but the use of an agreed-upon standard as the basis for comparison distinguishes measurement from judgment. Paintings are judged, pistons are measured. Judgment is the more widely applicable process. Measurement is possible only where a standard can be used. Measurement, where applicable, is the more definite and satisfactory, because all agree to compare with the same thing, the standard.

If practicable standards can be set up for at least some of the managerial functions and suitable methods of comparison also agreed upon, a part at least of the personal element used in evaluating management can be eliminated; and in so far as measurement can be thus substituted for judgment, to that extent will the rating become more trustworthy.

There is increasing need for more trustworthy evaluations of management because of:

a The increasing scale of production. Mistakes in management are more disastrous now than when production was on a smaller scale

b The widening of competition to a national and even international basis. To compete with foreign labor American productive facilities must be used to maximum advantage

c The narrowing margin of profit. In the easy-going days a generation or two ago, profits were large enough to permit inefficiencies of management which today would be fatal

d The development of management as a separate function. Formerly the manager was usually the owner. Now, more and more, he is acting for others who are the owners, and is responsible to them. It is desirable that the owners have better means for gaging the effectiveness with which their business is being managed, and that the managers be able to prove their work to the owners

e The diversity of the points of view from which management is, and must be, judged. The interests and personal views of those making these judgments lead to different estimates for the same set of conditions. In so far as they can agree upon a common method, it will be a benefit to all

f The rapid development in management methods. New methods are being tried, some wise, some not. We should be able to determine their effectiveness quantitatively, if possible; to pass judgment on them on the basis of actual fact, instead of predisposition, enthusiasm, or habit

g It is desirable to have some form of progressive judgment, to know what the management *is accomplishing*, not what it has done after crucial mistakes have been made.

It is a healthy sign that responsible industrial engineers and executives are the very ones who are most desirous to have their work measured. They are calling for it and will welcome it as a means for assisting them in their work.

The Effect of Measurement in Other Sciences. The great development of modern science has been based upon improvements in measurement. Before the application of measurement the sciences were largely speculative, practically useless, sometimes dangerous, and often a cloak for imposture. With the development of measurement they have grown exact, effective, and useful.

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Natural philosophy has become physics, alchemy has become chemistry, astrology has become astronomy, and modern medicine and surgery have developed from the blood letter and chirurgeon of the Middle Ages.[1]

There is every reason to believe that in so far as measurement can be applied to management, it will be of similar benefit. Measurement in management should

a Increase its practical utility
b Permit action with more practicable results, and
c Tend to sift the wheat from the chaff both in men and methods.

Use of Proven Methods. The answer to a new problem often comes through the application of methods and means which have been in successful use in other fields. We now have satisfactory means for measuring the performance of machines and of workmen in connection with commercial production, which are in daily use and of incalculable value in modern production. It is well to consider how far these may be applicable in the field of management.

MEASUREMENT IN ENGINEERING

Three elements are characteristic of measurement as applied to commercial production:

a An agreed-upon standard, the qualities of which we seek to approach or duplicate
b Agreed-upon units of measurement applicable both to the standard and to the things to be measured
c Means or methods of *impersonal* comparison of the thing to be measured with the standard by means of the agreed-upon units. Impersonality is the soul of measurement and is one of the elements which differentiate it from judgment. Different persons, properly qualified and in possession of the same facts, should be able substantially to duplicate the results.

As an embodiment of these three characteristics, we might have

As the standard (*a*), the barrel of a model rifle
As units of measurement (*b*), inches, degrees of curvature, hardness, etc. These can be used to express the desired qualities so completely that 10,000 barrels can be made from well-dimensioned drawings without the use of the model barrel
As methods of impersonal comparison (*c*), plug and ring gages, contour gages, etc., whereby any properly qualified person can determine the conformity of the production barrels to the model within the limits desired.

Phases Affecting the Problem. The use of these elements in actual production is scientifically correct and perfectly practical. They are used in the production of millions of dollars worth of material every day. It is worth while to see if their use cannot be extended from the material side of production to the more intangible executive side. In doing so, however, three phases should be borne in mind.

(*a*) *Break-Up into Functions.* It is a fundamental principle in science and engineering that a problem involving several variables can be solved only by segregating each variable, solving it separately, and then combining the results. Babbage recognized this as applying with equal force to problems of manufacture in his remarkable "Economy of Manufactures," written nearly 100 years ago. Management is a complex function involving a large number of variables and no satisfactory rating for it can be obtained unless this procedure is followed. This breaking down into separate elements was the basis upon which Mr. Taylor built up his methods of time study. The only hope for measuring management successfully is to extend his general method from the study of a single task to that of management as a whole.

(*b*) *Measurement by Reactions.* Science and engineering continually deal with quantities not directly measurable upon the principle that action and reaction are equal. If we can identify a cause and its effect, and can measure that effect, we have a measure of the cause of that effect. This principle may be utilized in this problem in evaluating some of the executive elements which are not themselves directly measurable.

(*c*) *Extreme Accuracy Not Essential.* Measurement does not have to be extremely accurate to be useful. If we measure in the same way each time, with the same units, and recognize that the results are approximate, we are far better off than with no measure at all.

CHARACTERISTICS NECESSARY IN ANY METHOD OF MEASURING MANAGEMENT

Any method of measuring management which has any hope of being successful must have the following characteristics, some of which have already been referred to:

a It must be sound, clear, and convincing
b It must be based on ascertainable facts
c It must reflect the conditions under which the management operates
d It must attempt to measure only such elements as are measurable
e It must be confined to those elements over which the management has control
f It must eliminate, as far as possible, the element of opinion in application, that is, be impersonal
g It must offer a better and sounder basis for measuring the managerial function than we now have
h It must be useful. It should give more than an overall efficiency, and should indicate, if possible, the relative strength and weakness of the various elements to serve as a guide for development and improvement
i It must be as simple as is consistent with the complexity of the problem to be solved.

The author feels that the various methods suggested up to this time fail in one or more of the characteristics given above.

The general procedure used in scientific and engineering measurement can be adapted to the measurement of some, at least, of the elements of management in a way which will satisfy these conditions.

With the above considerations in mind the following method is suggested:

a Break down the managerial function into component elements which may be considered separately
b Set up an ideal performance for each element
c Set up a standard of performance for each element which shall, if possible, conform to this ideal; if this is not possible, one which will give a practical working basis approaching that ideal and will mean the same thing to all. If *no* standard seems practicable at this time, this element may be omitted from the rating
d Set up a method of rating the performance of the management against each of these standards
e Develop a method of bringing together the individual element ratings, properly weighted, into a composite rating.

The final rating should be used with the understanding that it covers only those elements at present considered measurable and that the remaining elements, if any, which do not lend themselves to measurement are still to be evaluated on the basis of judgment as heretofore.

The application of the method which follows is given as illustrating a method of procedure. A more satisfactory division into elements is quite possible. The same is true for the standards and rating ratios set up. These can be established best by those familiar with the conditions in each industry. It is the method only which is emphasized. It will be confined to the field of production, because it is difficult at this time to set up satisfactory standards of performance and methods of ratings in the other fields. Progress is being made in this direction, however, and it is possible that standards and methods for measuring these elements will be developed. The method of analyzing financial statements given in the pamphlet issued by the Robert Morris Associates[1] is a step in this direction. The general financial statement is analyzed into eight ratios. These are weighted in accordance with the conditions of that industry, and brought together into a single rating based on unity. This approaches very closely the procedure set forth in this paper.

[1] Medicine is the least exact and certain of the sciences mentioned just because it is the one in which measurement is most difficult.

[1] "Financial Statements"—An explanation in brief of a system for analysis from the standpoint of the credit grantor and the business executive. Issued by the Robert Morris Associates, Lansdowne, Pa.

Division into Elements. For our present purposes production will be divided into the following elements:

a Purchasing
b Stores Inventory
c Efficiency of Plant, Equipment, and Methods
d Efficiency with respect to Materials Used
e Efficiency with respect to Payroll
f Idleness of Equipment
g Quality of Output
h Keeping of Promises
i Labor Turnover
j Cost Accounting and Records.

With each of these elements we will consider first the ideal performance in respect to this element; second, a practical standard for it, if one is possible; third, a rating ratio for measuring the performance against this standard.

Purchasing

Ideal.

a The securing of the right amount of material, of the right kind and quality
b At the lowest prices available, and
c Having this material on hand when it is wanted, where it is wanted, and in the condition wanted.

Practical Standard. The "right amount" is the least which will provide an uninterrupted supply for production and will maintain the minimum stores required for safe operation. If the proper minimum of the stores of the right kind and in the right condition is maintained at all times, there should be no interruptions of production from failure of raw-material supply. Items (*a*) and (*c*) above will be cared for under the element of Stores Inventory.

The "lowest prices *available*," item (*b*), are not readily ascertainable, and with long-time purchases are complicated by the cost of carrying charges. Current market prices are, however, usually obtainable and may be used in setting up a practicable working standard. Furthermore, in most manufacturing industries the bulk of the value of the total purchases is concentrated in a few basic raw materials.

If we could set up a ratio between the actual cost of these few basic materials used each day and their cost if bought "over the counter" at the market price that morning, we would have a fairly good measure of the purchasing efficiency for these materials. If the actual purchase cost were less than the current market, it would, when divided into the market cost, show a purchasing efficiency above par. If it were the same, the purchasing efficiency would be at par. If the purchase cost is greater, the ratio will be less than unity and the purchasing is below par. If this ratio is favorable for the basic materials, the multitudinous minor supplies which make up the relatively small balance may be disregarded.

Rating Ratio. It would be impractical to make this comparison on a daily basis, and comparison with the monthly average market prices would, in most cases, be sufficient. A practical rating for the purchasing function therefore may be expressed as follows:

$$\text{Rating ratio} = \frac{M_1 + M_2 + M_3, \text{ etc.}}{C_1 + C_2 + C_3, \text{ etc.}}$$

where

M_1, M_2, etc., are the products of the monthly consumption of a selected basic material multiplied by the *average market price* for that material during that month, and

C_1, C_2, etc., are the actual *costs* of these materials *as purchased.*

As pointed out above, if the materials have been purchased at low prices the values in the denominator will be less than the corresponding ones in the numerator. If desired, the ratio for each material may be taken separately, these added, and the sum divided by the number of materials to bring the result to a unit basis. Where the material has been carried a long time, interest and carrying charges may be added to the purchase cost, if that refinement is deemed necessary. Both numerator and denominator are in dollars and the quotient is a ratio for that month which may be less than, equal to, or greater than unity, according as the given materials have been bought above, at, or below the average market prices for that month.

The rating of the purchasing element may be based on the running average of the ratios for the past twelve months instead of a single monthly ratio. Such an average would be fairer than a single ratio, as it will show how well the purchasing department is anticipating prices.

Stores Inventory

Ideal. The maintenance at all times of the lowest amount consistent with having all the material ready for process, when, where, and in the condition needed.

Practical Standard. For simplification, instead of considering all the stores, the same basic raw materials may be used for this element as in the case of purchasing.

Set up for each basic material the minimum safe time which should be allowed to order and obtain that material, with due consideration to distance, reliability of source, contingencies, etc., in accordance with the present well-established practice. These times may, and probably will be, different for each material, and may vary with market conditions.

If three months, for instance, was the safe time allowance on, say, January 1 for obtaining one of these materials, then the sum of the consumptions during January, February, and March is the amount of stores which should have been on hand at that date. This can be used as a standard, and can be divided into the actual stores of the material on hand at that time. This will give a ratio which will be less than, equal to, or greater than unity according as the stores actually on hand were less than, equal to, or more than the safe amount needed. A similar ratio may be set up for each of the basic materials. A moving average for, say, one year of the deviation of the percentages from unity for each material, *disregarding the sign*, i.e., whether the deviation is above or below unity,[1] will indicate how close the stores inventory on that material had been kept to the desirable minimum.

To obtain the ratio for the stores inventory as it stands at the *present* time it is necessary to use the estimated requirements, through the production or sales schedules, as this is the best information we have.

Rating Ratio. The rating ratio can be obtained from the average of the moving averages for the various materials, again disregarding the sign, i.e., whether the deviation is above or below unity. This average deviation should always be *deducted* from unity to obtain the rating.

Unity in this rating would indicate that the management had uniformly maintained the stores inventories of its basic materials at the minimum which had been established as good practice and under the conditions of operation. Ratings less than unity would indicate how far the inventory had been departing from this standard. Examination of the monthly figures would show when, in which materials, and in which directions the deviations had occurred.

For the detail planning and follow-up of the material stores we have in the Gantt layout and progress charts a useful and tried-out method which in itself is an excellent measure of the performance of this function. It does not, however, head up into a single rating as the method suggested does, but can readily be used in connection with it.

Effectiveness of Production

Ideal. The production of the greatest value of salable output with the least expenditure for plant, materials, and labor.[2]

This has three aspects. Production efficiency with respect to

a Plant, equipment, and methods
b Materials
c Labor employed.

A management may be making poor use of a good plant and equipment, or the best possible use of a poor equipment. It is desirable, therefore, to measure these phases separately. This can be done roughly by dividing the product sold per annum in case (*a*) by the plant investment, in case (*b*) by the materials

[1] If the signs of the deviation are not disregarded, plus and minus deviations would offset each other and tend to show conformity to the required quantities when such conformity did not exist. If the deviations are averaged arithmetically without regard to whether they are above or below, we will get a true measure of the conformity.

[2] With respect to labor this should be construed as the least expenditure consistent with sound social conditions, to exclude child labor, etc.

purchased annually, and in case (*c*) by the total annual payroll. The products *sold* is in general a better value to use than the value of the goods produced, because it represents goods which actually contributed to the income. In certain businesses, such as heavy machinery or shipbuilding, however, the goods produced, including even those only partly finished, may be the better value to use.

Practical Standard. These ratios will of course vary with different industries, and it is necessary to compare them with some standard before we can know whether they are high or low. The most practical standard seems to be the similar ratio for the industry as a whole. Various Government reports such as the 1919 Census of Manufactures and the Statistical Abstract of the U. S. give the capital invested, value of the products, value of the materials used, and total payroll for many industries.[1] There are other sources also, such as trade associations, so that in most cases the information necessary for the comparison is available.

Rating Ratios. If the ratios for the industry are available the rating for efficiency with respect to plant, equipment, and methods would be

$$\frac{\text{Annual sales in dollars}}{\text{Plant investment in dollars}} \div \frac{\text{Total annual output of the industry}}{\text{Total investment in the industry}}$$

The result will be above, equal to, or less than unity according as the ratio for the firm in question is better, equal to, or worse than the average of its competitors. In times of extreme depression it may be fairer to divide this ratio by the idleness ratio, given later under Idleness of Equipment.

The rating with respect to materials would be

$$\frac{\text{Annual sales in dollars}}{\text{Total annual purchase of materials}} \div \frac{\text{Total annual output of the industry}}{\text{Value of raw materials used in industry per annum}}$$

Similarly, the rating with respect to use of labor would be

$$\frac{\text{Annual sales in dollars}}{\text{Total annual payroll in dollars}} \div \frac{\text{Total annual output of the industry}}{\text{Total annual payroll of the industry}}$$

These ratios may be above unity and will show ratings on the basis of the average for that industry or the average of the competition which the firm has to meet.

The material turnover would also be a useful element to measure, but no standards or methods of rating seem to be available. If these could be satisfactorily set up it would be desirable to include it.

Idleness of Equipment

The degree of approach of the actual output to the full capacity of the plant is a significant means for measuring management. In reality it is included in the plant-efficiency ratio above, but it shows directly what use is being made of the equipment and is so easily obtained and is so useful that it is well to set it up separately. Mr. Gantt told the author that he used it continually in diagnosing the situation in a plant.

Ideal. The ideal would of course be to have all the equipment at work at full capacity all the time. Of course, also, this is impossible.

Standard. The same, i.e., 100 per cent or the full capacity of the plant.

Rating Ratio. This would be

$$\frac{\text{Actual production machine hours}}{\text{Machine hours' capacity of the plant}}$$

For each industry the ratio would have a characteristic maximum, always less than unity.

Quality

Ideal. That all goods produced pass all inspections, both producer's and customer's.

Standard. The same, i.e., 100 per cent of the goods produced.

Rating Ratio. This would be

$$\frac{\text{Goods produced which pass all inspections}}{\text{Total goods produced}}$$

This rating will presumably always be less than unity, and it may be in certain cases, as in some garment industries, that a moderate proportion of "seconds" is preferable to the expense of trying for perfection.

Promises

Ideal. All promises kept.

Standard. The same.

Rating Ratio.

$$\text{Rating ratio} = \frac{\text{Number of promises kept}}{\text{Number of promises made}}$$

This rating also will, in general, be less than unity.

Labor Turnover

Ideal. That turnover, only, which is due to inevitable causes, such as death, superannuation, marriage; seldom, if ever, attainable.

Standard. The turnover prevailing in that trade and locality, so far as these can be determined.

Rating Ratio.

$$\text{Rating ratio} = \frac{\text{Turnover of plant under consideration}}{\text{Turnover of that trade and locality}}$$

Cost Accounting and Records

Ideal. The gathering and maintaining of information on all costs which shall be

a Accurate
b Prompt
c Useful, *and used*
d Tied in with the production and financial accounts.

This element is vital in modern management. The author has been unable to discover a standard or means of *measuring* performance in it which would be satisfactory or generally applicable. The best way would be to recognize this frankly; to set up an ideal, and to rate the performance of the management in this element on the basis of judgment of men properly qualified to pass on it.

The Final Rating

The element ratings may be brought together into a final rating as follows:

	(1) Element	(2) Individual rating of element	(3) Percentage weight of element in total rating	(4) Weighted rating of element (col. 2 × col. 3)
a	Purchasing			
b	Stores Inventory			
c	Efficiency of Plant, Equipment, and Methods			
d	Efficiency with Respect to Materials Used			
e	Efficiency with Respect to Payroll			
f	Idleness of Equipment			
g	Quality of Output			
h	Keeping of Promises			
i	Labor Turnover			
j	Cost Accounting and Records (on basis of judgment)			
			100%	
	Final Rating			

The separate elements and their ratings as obtained above may be listed as in columns 1 and 2. Percentage weights for each element, suitable for that industry, are set up in column 3; and the weighted value for each element (column 2 × column 3) is extended in column 4. The final or combined rating will be the sum of the items in column 4. Values above unity in the element ratings for *a*, *c*, *d*, *e*, and *i* would indicate that the quality of the management, in these elements, was better than the average of the industry; values below, that it was poorer.

The ratings in column 2 are founded on ascertainable facts and are largely free from opinion or judgment. The weights in column 3 assigned to the various elements, however, must involve judg-

[1] Appendix 2 gives this data for certain selected industries. The Statistical Abstract of the U. S. gives it for more than 300 industries, in addition to those listed in the appendix.

ment, which will of course affect the weighted ratings in column 4. If this is objected to, the use of the method can stop with column 2. A periodic comparison of the variations in the element ratings in that column will, alone, have value in guiding management policies. If our purpose is to measure the management as a whole we must recognize that the elements will have different relative importance in different industries, and they must be weighted to reflect the conditions for each industry. After all, as we have said, extreme accuracy is not required. If some weighting can be *agreed upon* for the industry in question, and all concerned will use that weighting, then column 4 and the Final Rating will have value as a basis for comparison.

UTILITY OF THE ABOVE METHOD

The method outlined furnishes a basis for comparing managerial performance in different plants of the same or allied industries, but more particularly it offers a means of following variations in the management of a single plant.

The element ratings and the final rating may or may not have considerable significance where applied once to a specific business, as of a certain date. If, however, the method be used repeatedly, in the same way, each successive set of ratings will become more trustworthy and useful because we have set up a uniform and orderly basis of comparison for the measurable elements of the executive function.

APPENDIX NO. 1

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(*Continued on page 669*)

APPENDIX NO. 2

INFORMATION ON CERTAIN INDUSTRIES FOR THE CALENDAR YEAR 1919

NOTE.—The industries given below are selected out of more than 350 listed in Table No. 160, p. 226, of the Statistical Abstract of the U. S., 1921, from which columns 1 to 5 are taken. The ratios given should be used with caution as the year 1919 was one of abnormal production. The table brings out clearly, however, how widely the ratios vary as between different industries.

1	2	3	4	5	6	7	8
					Ratios of Value of Annual Output to		
Industry	Capital, Dollars	Wages, Dollars	Cost of materials, Dollars	Value of products, Dollars	Capital	Wages	Cost of Matls.
Agricultural implements	366,962,052	66,704,434	144,571,943	304,961,265	0.83	4.57	2.11
Automobile bodies and parts	470,497,552	178,955,503	362,027,302	692,170,692	1.47	3.87	1.91
Automobiles	1,310,451,400	312,165,870	1,578,651,574	2,387,903,287	1.82	7.65	1.51
Boots and shoes, not including rubber boots and shoes	612,625,075	210,734,610	715,269,315	1,155,041,436	1.88	5.48	1.62
Boots and shoes, rubber	131,513,436	30,882,722	50,346,880	116,917,434	0.89	3.78	2.32
Brass, bronze, and copper products	325,299,738	94,132,118	304,823,580	482,312,790	1.48	5.13	1.58
Bread and other bakery products	529,265,779	158,237,059	713,239,411	1,151,896,318	2.18	7.29	1.62
Brick and tile, terra cotta, and fire clay products	355,848,355	78,256,085	67,488,113	208,422,920	0.59	2.67	3.10
Butter	162,302,108	19,052,729	514,345,739	583,161,011	3.60	30.60	1.13
Canning and preserving, fruits and vegetables	223,692,234	43,592,537	265,628,525	402,242,972	1.80	9.23	1.52
Cars and general shop construction and repairs by steam-railroad companies	694,286,410	687,617,312	515,803,210	1,279,235,393	1.84	1.86	2.48
Cars, steam-railroad, not including operations of railroad companies	335,207,363	78,284,647	356,084,545	538,222,831	1.61	6.88	1.52
Cement	271,269,259	33,194,920	79,509,800	175,264,910	0.65	5.29	2.21
Chemicals	484,488,412	72,848,324	216,301,279	438,658,869	0.91	6.02	2.03
Clothing, men's	554,147,279	197,821,990	605,752,176	1,162,985,633	2.10	5.90	1.92
Clothing, women's	390,526,517	195,295,834	680,406,844	1,208,543,128	3.09	6.19	1.77
Coke, not including gas-house coke	365,249,622	42,299,292	224,266,673	316,515,838	0.87	7.49	1.41
Confectionery and ice cream	317,043,923	76,159,866	368,809,170	637,209,168	2.01	8.37	1.72
Cotton goods	1,853,099,816	355,474,937	1,277,785,597	2,125,272,193	1.15	5.98	1.66
Dyeing and finishing textiles, exclusive of that done in textile mills	299,948,486	57,189,978	174,742,815	323,967,683	1.41	5.66	1.85
Electrical machinery, apparatus, and supplies	857,855,496	238,188,852	425,098,211	997,968,119	1.16	4.20	2.34
Engines, steam, gas, and water	454,124,733	105,435,455	217,550,771	464,774,735	1.02	4.41	2.14
Explosives	133,247,684	12,504,986	45,911,049	92,474,813	0.69	7.40	2.01
Flour-mill and grist-mill products	801,624,507	50,888,383	1,799,180,987	2,052,434,385	2.56	40.40	1.14
Food preparations, not elsewhere specified	245,282,687	29,392,209	494,597,157	631,598,150	2.58	21.50	1.28
Foundry and machine-shop products	2,104,980,938	622,571,129	948,069,381	2,289,250,859	1.09	3.68	2.41
Furniture	423,992,405	141,116,316	261,523,395	571,356,333	1.35	4.05	2.18
Gas, illuminating and heating	1,465,656,265	52,758,628	157,550,882	329,278,908	0.22	6.24	2.09
Hardware	133,925,619	45,229,950	58,533,769	154,524,888	1.15	3.42	2.64
Ice, manufactured	270,725,786	34,001,837	42,877,509	137,004,798	0.51	4.03	3.20
Iron and steel, blast furnaces	802,416,541	73,769,395	621,286,496	794,466,558	0.99	10.80	1.28
Iron and steel, steel works and rolling mills	2,656,518,417	637,637,430	1,680,575,758	2,828,902,876	1.06	4.44	1.68
Knit goods	516,457,991	125,199,820	427,095,560	713,139,689	1.38	5.69	1.67
Leather, tanned, curried, and finished	671,341,553	88,205,473	646,521,527	928,591,701	1.38	10.51	1.44
Lumber and timber products	1,357,991,571	489,419,091	470,960,488	1,387,471,413	1.02	2.84	2.95
Lumber, planing-mill products, not including planing mills connected with sawmills	361,848,079	91,976,526	299,265,652	500,438,258	1.38	5.45	1.67
Machine tools	231,039,843	66,178,969	59,034,308	212,400,158	0.92	3.21	3.59
Oil and cake, cottonseed	203,457,371	20,615,193	495,192,294	581,244,798	2.86	28.20	1.17
Paints	177,314,815	19,550,371	165,604,116	256,714,379	1.45	13.12	1.55
Paper and wood pulp	905,794,583	135,690,642	467,482,637	788,059,377	0.87	5.82	1.69
Petroleum refining	1,170,278,189	89,749,637	1,247,908,355	1,632,532,766	1.39	18.20	1.31
Prin ing and publishing, book and job	446,554,984	141,476,243	211,067,174	597,663,228	1.34	4.23	2.83
Printing and publishing, newspapers and periodicals	614,045,344	144,348,173	300,385,187	924,152,878	1.51	6.40	3.15
Rubber tires, tubes, and rubber goods, not elsewhere specified	782,637,722	156,806,828	525,686,309	987,088,045	1.26	6.29	1.87
Shipbuilding steel	1,268,640,254	538,372,576	643,752,814	1,456,489,516	1.15	2.70	2.26
Shirts	102,012,047	25,833,855	127,087,745	205,327,133	2.01	7.95	1.62
Silk goods	532,732,163	108,226,330	388,469,022	688,469,523	1.29	6.36	1.77
Slaughtering and meat packing	1,176,483,643	209,489,263	3,782,929,533	4,246,290,614	3.61	20.30	1.12
Smelting and refining, copper	308,680,268	25,723,371	584,410,173	651,101,591	2.11	25.30	1.12
Soap	212,416,866	21,228,063	238,518,858	316,740,115	1.49	14.90	1.33
Tobacco, cigars, and cigarettes	416,395,472	111,313,348	353,297,366	773,662,495	1.86	6.95	2.19
Tools, not elsewhere specified	134,731,947	43,836,069	45,796,967	144,201,668	1.07	3.29	3.15
Steam fitting and steam and hot-water heating apparatus	133,097,464	45,742,525	72,016,393	160,285,488	1.20	3.50	2.22
Stoves and hot-air furnaces	122,813,373	41,321,133	54,803,316	145,717,963	1.19	3.53	2.66
Structural ironwork, not made in steelworks or rolling mills	219,470,095	59,920,132	168,800,715	294,962,419	1.34	4.92	1.75
Sugar, beet	224,584,679	15,908,118	87,029,144	149,155,892	0.67	9.40	1.71
Sugar refining, not including beet sugar	193,540,825	22,710,464	662,143,981	730,986,706	3.79	32.19	1.11
Wire	102,016,777	29,289,667	102,813,591	162,151,236	1.59	5.55	1.58
Woolen and worsted goods	831,694,748	168,108,681	665,594,683	1,065,434,072	1.28	6.34	1.60

The Water, Coal, and Man Power of the Western Slope of the Southern Appalachian Mountains

By J. A. SWITZER[1] and W. R. WOOLRICH,[2] KNOXVILLE, TENN.

THE purpose of this paper is to correlate our present knowledge of the water powers of the western slope of the Southern Appalachian Mountains with the coal resources and with the labor resources of the region. At a recent meeting of the Southern Appalachian Power Conference, Mr. Frank G. Baum, of California, calmly said that within a period of 20 years all of the water power of the United States will have been developed. This seems a super-bold prediction; yet if a curve of growth of the hydroelectric industry be plotted, it is not difficult to so project the curve beyond the present as to justify such a prediction. Mr. Baum's dream of a single superpower system, covering the United States like a benign blanket, is daily being wrought into reality—and before we know it, the thing will be done! However this may be, the isolated steam plant is already superannuated and will soon be superseded. The future of steam power is intertwined with water power, and our interest in it now is to find the most strategic locations for the placing of large base-load plants.

However, absorbing and essential as are considerations of cheap power, whether derived from water or from steam, the matter of greater importance to industry is man power, that is to say, the labor supply.

During the World War we came to realize that the congested district centering around New York was somewhat overindustrialized. If this section is to maintain its past rate of industrial growth, dependence must be placed upon immigrant labor. Because of vested interests, human inertia, and the provincial outlook of those whose knowledge of America does not extend beyond the metropolitan district, no sudden decline need be looked for in this industrial beehive.

The western slopes of the Southern Appalachian mountain chain possess advantages to industry not yet fully appreciated except, perhaps, in limited circles. Altitudes lifting the country above the general level modify the climate which the latitude alone would determine. Yet the latitude does insure a mildness of climate which liberates life from the rigors of the North. The abundant rainfall characteristic of the region results in a regimentation of stream flow which to northern hydroelectric engineers is a never-ending source of amazement. Not only does the resulting high annual rate of run-off surprise them, but as well the high summer rates of flow and the absence of the excessive winter and spring floods to which their experience on northern streams has accustomed them.

An abundance of coal of high quality, and in many places the availability of adequate condensing water at naturally low tem-

FIG. 1 MAP OF THE SOUTHERN APPALACHIAN REGION SHOWING THE TRANSMISSION SYSTEMS THUS FAR BUILT

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peratures, are factors. And finally here is found a population more purely of Anglo-Saxon strain than can be found elsewhere in the country. The combination of these factors is a matter of more than local interest. It is the purpose of this paper to merely touch lightly upon this theme.

THE PRESENT STATUS OF THE POWER INDUSTRY

Fig. 1 is a map showing the transmission systems of the Southern Appalachian region as built to date. In 1905 the nucleus for future growth was planted by the Southern Power Co., which in that year built the first mile of high-tension transmission line in this region. During the years from 1905 to 1912 the system slowly spread over the Piedmont Plateau, or that portion of it occupied by the Southern Power Co.

In the year 1912 the Watauga Power Co. built 17 miles of transmission line and delivered Watauga River power to the City of Bristol. Within a few days of the opening of this line, the Tennessee Power Co. (now the Tennessee Electric Power Co.) began to furnish power to Knoxville and to Chattanooga from the Ocoee River. Later in the year the Georgia Railway & Power Co. opened the turbine gates at Tallulah Falls and the power of the Tallulah River flowed into Atlanta.

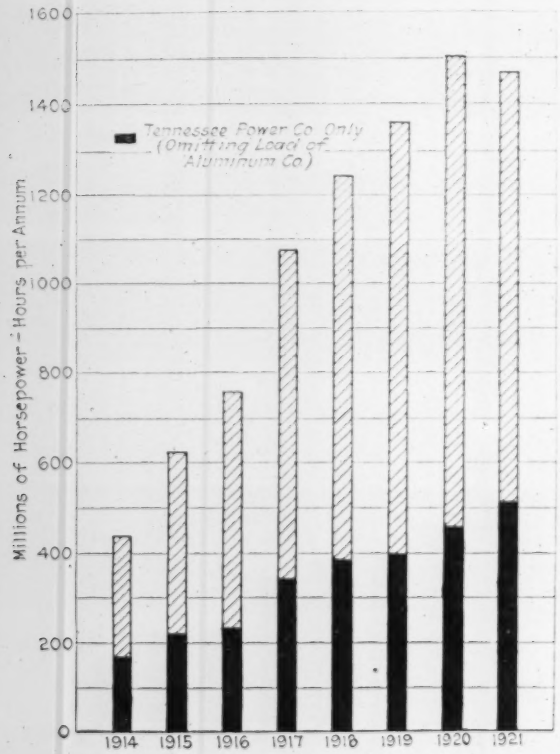

FIG. 2 COMBINED POWER OUTPUT OF THE ALABAMA POWER CO., THE GEORGIA RAILWAY AND POWER CO., AND THE TENNESSEE POWER CO.

In 1913 Birmingham began to receive power developed by the Alabama Power Co. at Lock Twelve, on the Coosa River.

From these centers transmission lines began to radiate; and extensions, ramifications, and interconnections have finally knit the Southern Appalachian region into the most extensive 110-kilovolt superpower system existing in the world today—a system with an aggregate mileage exceeding 5000 which is still growing vigorously, and no doubt will continue to grow for some years to come.

It may be of interest to review somewhat in detail the growth of this hydroelectric industry; and here are given some pertinent facts and figures.

The growth of the business of the Alabama Power Co. is shown in Table 1. This table shows that in the year 1920, 8.36 times as much power was generated as in 1914, and during 1922, 10.4 times as much—a growth of 1000 per cent in eight years.

TABLE 1 CONNECTED LOAD AND POWER OUTPUT OF THE ALABAMA POWER COMPANY

Year	Connected Load, hp.	Total Power Generated, hp-hr.
1913	16,500	26,000,000
1914	47,000	78,000,000
1915	62,000	171,200,000
1916	116,000	252,000,000
1917	184,000	394,000,000
1918	265,000	537,000,000
1919	287,000	476,000,000
1920	336,000	654,000,000
1921	362,000	584,000,000
1922	403,936	814,000,000

The Georgia Railway & Power Co. began selling steam-generated power in 1903, and by the year 1914 had largely matured their market for power. Nevertheless, the total power either generated in their own plants or purchased by them from the Alabama Power Co. and the Tennessee Power Co. amounted in 1920 to 393,000,000 hp-hr., against 196,000,000 in 1914.

The Tennessee Power Co. began selling power in 1912. Their power output in 1914 was 304,200,000 hp-hr. In March, 1914, they began supplying power to the Aluminum Company of America, for the Maryville reduction plant; and during 1914 this company took 134,000,000 hp-hr., or about 44 per cent of the entire power output. In 1916 the Tennessee Power Co. generated 636,500,000 hp-hr., and the Aluminum Co. absorbed 64.6 per cent of the power sold. In 1917 the power generated was 735,000,000 hp-hr., and the Aluminum Co. used 62.45 per cent of the power sold. The Aluminum Co.'s peak load reached 54,000 hp. in that year; but later the load fell off, and in 1920 but 23 per cent of the power output went to the Aluminum Co., and in 1921, less than 8 per cent. On June 1, 1921, the Aluminum Co. ceased to be a customer, having completed its own power plant at Cheoah, on the Little Tennessee River. Yet so rapidly have the general requirements for power in the territory served by the Tennessee Power Co. increased, that the present generating capacity of 168,000 hp. is inadequate to meet the demand. The company is now building two additional steam plants, each of 27,000 hp. capacity, one at Nashville and one at the hydro plant at Hales Bar. The hydro plant at Great Falls is also being enlarged by the addition of a second 12,000-hp. hydraulic turbine.

All over the territory considered in this paper like conditions are seen. Construction of new power plants can scarcely keep pace with the growing demand for more power; and one authority recently remarked that the southern power companies are today 25 per cent behind the power market requirements. Everywhere intense construction activity is in evidence.

The Kentucky Utilities Co. is just completing a steam plant at Pineville having a present generating capacity of 40,000 hp. and a future capacity of 60,000, and will shortly start work on a hydro plant on the Dix River.

The Tennessee Eastern Electric Co. is adding to their two units on the Nolichucky River two more, and they will shortly be at work increasing the height of their dam from 35 ft. to 70 ft., thus more than tripling their present hydro generating capacity. They are also building a steam plant of 13,000 hp.

Both the Tennessee Electric Power Co. and the Knoxville Power & Light Co. have filed with the Federal Power Commission applications for permits to make very large developments on the Tennessee River, the Clinch River, and the Powell.

With a present generating capacity of 195,600 hp. of hydro and 30,800 of steam power, the Georgia Railway & Power Co. is just finishing construction of an 84,000-hp. plant on the Tugaloo River. In addition to this total generating capacity of 265,400 hp., this company owns 303,000 hp. of undeveloped or partially developed water power.

The Alabama Power Co. is just adding to its present generating capacity of 200,900 hp., 72,000 hp. more at the Mitchell dam on the Coosa River. Permits have been secured from the Federal Power Commission for four dams to be built on the Tallapoosa River; but before building these the company will first build plants to be called Upper Tallassee, Cherokee Bluffs, and Lower Tallassee, and will follow these by a plant at Lock 18, below the Mitchell dam on the Coosa. Designs for the first three of these are now being worked out.

So heavy has been the demand for power in these several states that for the last two years the Alabama Power Co. has leased the 80,000-hp. steam plant built by the Government during the war at

the nitrate plant at Sheffield, and this plant has served as an auxiliary to the constituent companies in the superpower system.

The Southern Power Company, with a present generating capacity of approximately 300,000 hp., will this year complete two new hydro plants, one at Mt. Holly, N. C., and one at Great Falls, S. C., which will add another 140,000 hp.

In addition to this, construction of two more steam plants with a combined capacity of 60,000 hp. will bring the total generating capacity of the Southern Power Co. to about 500,000 hp.

The growth of the power business in this region is further graphically shown by the diagram, Fig. 2.

The Changing Aspects of the Power Industry

What estimate, we should like to ask, would be made of the sanity of any engineer who might propose to pump water from a river flowing through Alabama into the Gulf of Mexico through a pipe line terminating in a reservoir located on another river, flowing eastwardly through North Carolina, into the Atlantic Ocean, 650 miles away? And merely for the sake of there using the water for developing power! Absurd as this proposal may seem, this very thing has virtually been done—though the pipe was solid, and made of copper. On a certain day not long since, copious rains occurred on the head waters of the Coosa River. The small reservoir of the Alabama Power Co. at Lock Twelve on the Coosa River was full, and so could not conserve this flood flow. The flow could be utilized, if at all, only as it came down the river; and passing over the dam, its energy would be forever gone. But away off to the east, on the eastern slope of the Piedmont Plateau, the reservoir of the Carolina Power & Light Co., on the Pee Dee River, had been drawn down, and an insufficient stream flow meant a shutting down, or at least curtailing of output, of the many cotton mills in and around Raleigh dependent on this water power. And so for a time the turbine gates at the Blewett Falls plant of the Carolina Power & Light Co. on the Pee Dee River were closed; and while the reservoir was thus allowed to be replenished by the flow entering it, the load of the company was carried by power relayed to it by the Southern Power Co., which in turn received it from the Georgia Railway & Power Co., to whom it was delivered by the Alabama Power Co.—power generated by the flood flow of the Coosa River! Here indeed was conservation doing real work!

This incident symbolizes the immense good which can and does come of the interconnection of large transmission systems. Among water-power engineers it has become a trite saying that interconnection converts secondary power into primary power. Recently, the manager of a large power company said: "Our company had completed the plans for a million-dollar auxiliary steam plant. But our experience since we became interconnected with our power neighbors has retired the plans to a filing cabinet. We believe now we shall not need the steam plant, or at least not in the immediate future."

In the Southern Appalachian region the fact that prolonged summer drought is the exception and not the rule, and the further fact that summer rains while frequently copious are also often closely localized, intensifies the obvious advantages of interconnection. Beyond this, the fact that a part of the region operates on eastern time and a part on central time introduces a diversity factor of no little value as contributing to the conservation of the water-power resources of the region. The process of interconnection has by no means more than begun, and one must indeed be a prophet who shall say where it will end.

The aspects of the power industry are changing so rapidly that we can see but a little way ahead. It is usually assumed that in the unfolding of the development of our water-power resources those power sites which can be the most cheaply utilized are those first developed; and that as the successive developments come in, the most expensive will come last. This, however, is not the case. Such would be the logical sequence if, at the outset, all our water-power resources had been fully studied, and all the complex factors entering the problem of each power development had been envisaged. The very fact that this logical order has not been even approximated gives a zest to the water-power game, as every hydroelectric engineer knows. In the Southern Appalachian region there are among the undeveloped water powers a number as large and certainly as attractive as any yet broken to harness.

Although according to the various reliable estimates of our total water-power resources we have as yet developed only a small fraction, the wonder is that we have made even this much progress. None but those in the business of water-power development realize the cost of making adequate preliminary investigations. Legislators and statesmen in particular have been slow to grasp the implication of this fact. It is for this reason that even today our knowledge of just what are our undeveloped power resources is not complete. There are, however, hopeful signs of a glad awakening; and perhaps the most significant of these is the Congressional approval of the recommendation by the chief of engineers for a real survey of the power and navigation potentialities of the Tennessee River basin. Think of what it means to national progress when the Chief of Engineers, and the Secretary of War can ask Congress to appropriate the sum of $515,800 for the survey of a single (if important) river system, and Congress can appropriate $200,000 for a beginning of this survey! The survey is now in progress, under the direction of Maj. Harold C. Fiske, Corps of Engineers; and two years will be required for its completion. In the meantime many surveys of single projects or of related projects are being rapidly carried forward by private interests.

The state of North Carolina, through the Geological and Economic Survey, by coöperation of certain counties in that state, is also carrying forward investigations within these counties. The State Geological Survey of Tennessee has now in press a Bulletin by J. A. Switzer describing a number of undeveloped water powers in Tennessee. In Alabama the legislature has just appointed a commission to study and report on the undeveloped water powers of that state.

A Study of Base-Load Steam Plants

The title of this paper, in referring to the coal power resources of the region under discussion, did not contemplate any detailed enumeration of the coal resources, but rather a discussion only of the problems connected with the development of large steam plants essential to the superpower system.

The installation of base-load steam plants at the coal-mine mouth has constituted an interesting and popular topic of discussion in all coal sections. To the layman it appears that the logical solution for the distribution of all coal-generated power is over the wires.

There are several advantages in such a system. It relieves the management of the generating station of the menace of a car shortage. It permits the use of certain low-grade fuels that it otherwise would not pay to use. It saves the freight charge on the coal that is used.

Other factors enter, however, that are of greater importance than those just mentioned. The most important one is the availability of adequate condensing water. Second only to this must be security of the coal supply—some form of anti-coal-strike insurance.

These two factors are of such predominating importance that to meet the requirements of a successful base-load station at the coal-mine mouth, it must be definitely provided that such a power plant must be located on a river which will give sufficient minimum flow to meet all condensing requirements, and that it must be sufficiently near a transportation system to put it in immediate haulage connection with several coal mines and, if possible, other coal fields.

Briefly, then, the requirements are a coal mine, a river, and more coal mines.

Of vital importance also is the matter of market for the power. Within the area covered in this discussion, the market is assured. The natural resources of the district are of such magnitude and diversity that the demand for power has grown in a much greater ratio than the power developments.

To emphasize the great influence which condensing-water supply must necessarily exert in selecting the location of the steam station, a typical water-demand curve is presented in Fig. 3.

Fig. 4 shows the river flow in cubic feet per second required to furnish condensing water for plants of various sizes when operating at 28½ in. of vacuum, referred to sea level, and with cooling water at 60, 70, and 80 deg. fahr., respectively.

A study of Fig. 3 shows that for a vacuum of 28½ in. referred to

sea level, with water at 70 deg. fahr., there is required a minimum of practically 385 tons of cooling water per ton of coal burned, on the basis of 9 lb. of evaporation. Most evidently the cost of securing condensing water is a very vital factor.

Not only is the quantity of water available important but its temperature also. Fortunately for the entire Southwestern Appalachian section, the water of the several streams is remarkably cool, usually being below 70 deg. fahr. even during the hottest weather. This is due to the source of the supply, practically all streams being fed by cold mountain springs. As we go out into the plains,

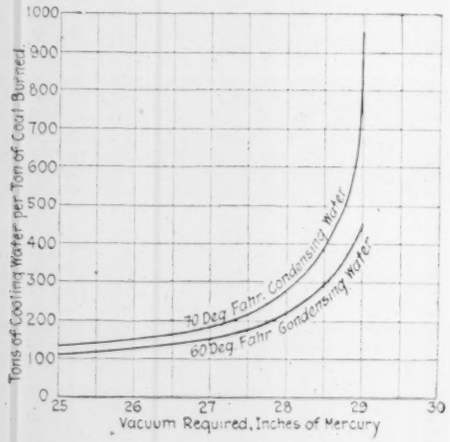

FIG. 3 CONDENSING-WATER REQUIREMENTS OF STEAM POWER STATIONS
(Based on the evaporation of 9 lb. of water per pound of coal burned.)

however, river temperatures will average from ten to fifteen degrees higher than those of the mountain sections.

Where an insufficient volume of naturally cool water is available, the alternative of artificial cooling of a limited supply is some times to be considered. In this section spray cooling at midday during the height of summer cannot bring temperatures below 80 deg. fahr., and this temperature of condensing water precludes high-vacuum operation, since the boiling point of water at a vacuum of 28½ in. is only approximately 90 deg. For the operation of very large steam plants, spray cooling is therefore of doubtful expediency.

For small plants, however, spray cooling is sometimes desirable; and when this is the case the mountain section again has an advantage over the lowlands for the reason that here lower relative humidities prevail, and hence the cooling effect of spraying is greater. An engineer of the authors' acquaintance was recently called in by a coal operator to install a 300-kw. non-condensing turbine. The water supply available was limited, and both the purchaser and the representative of the turbine manufacturer with whom the order had been placed felt certain that a condensing unit could not be considered. Both were amazed at the logic of the engineer, who finally convinced them that the scarcity of water actually made the condensing outfit the more desirable. When he proved to them that the loss of water by evaporation and by drift from a spray pond would be much less than the difference between the steam consumption of the condensing and the non-condensing turbine, the order was changed and the condensing turbine installed. Less actual water was required to operate the condensing unit!

Coming now to a consideration of possible sites for large steam plants, reference is made to Fig. 5. This map shows the location of operating coal mines, each dot representing a mine. The coal district reaches from the Harlan field in Kentucky to the Cahaba and Warrior fields in Alabama, with coal deposits well distributed in between. The Harlan district and the Middlesboro district of Kentucky hold some of the greatest coal operations of the entire Southern Appalachian region—many of these belonging to the great steel corporations. The section is well served by railroads.

The numerals on the map—seven in number—indicate what to the authors seem attractive locations for base-load plants. A thorough survey of the field would doubtless reveal others.

These locations may be briefly discussed as follows:

The Pineville, Ky., site (No. 1) is strategically located at the junction of two branches of the Louisville & Nashville Ry., leading to the Harlan and to the Middlesboro fields. This connection makes Pineville a center of coal transportation. The Cumberland River passes through the heart of the city and parallels the railroad for some miles. Several large coal mines are located close to the river at the outskirts of Pineville. Thus, the location has the requisite advantages for the location of a large coal-mine-mouth superpower station. The condensing water available is sufficient to provide during the very warmest and driest seasons for a generating capacity of from 75,000 to 100,000 kw. The Kentucky Utilities Co. now have under construction near Pineville a 45,000-kw. steam power plant to serve their system for this area.

The industrial demand of this section is such that the entire condensing capacity of the Cumberland River might well be utilized in the near future.

Passing southward, the second base-load steam plant indicated is located between Coal Creek, and Clinton, Tenn., on the Clinch River. This location is a few miles from any one coal mine, but sufficiently near to a group of good producing mines in the Coal Creek district to furnish coal by railroad for only a switching charge.

The condensing capacity of this river is sufficient to take care of a turbine capacity of from 400,000 to 450,000 kw. A large hydroelectric plant is being considered near this location at the present time, and the base-load site suggested is in very close proximity to a high-tension line now being built.

Plant No. 3 has been indicated on the map at Harriman, Tenn., on the Emery River. Like the Coal Creek site this location is not at any coal mine, but is suggested on account of Harriman's excellent railroad connections through four different carriers to four different fields. Several producing mines are only a few miles from the location. The minimum flow of the Emery River here

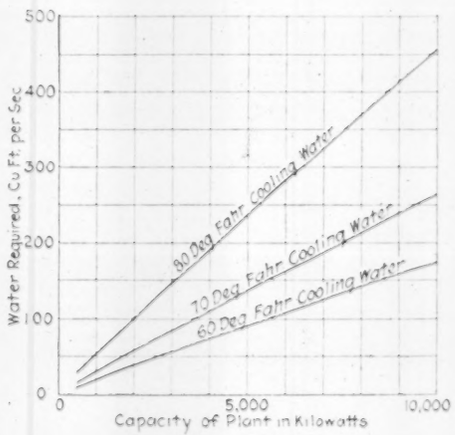

FIG. 4 CONDENSING-WATER REQUIREMENTS OF PLANTS OF VARIOUS SIZES WHEN OPERATING AT 28½ IN. OF VACUUM REFERRED TO SEA LEVEL AND WITH COOLING WATER OF DIFFERENT TEMPERATURES

will limit an installation to 75,000 to 100,000 kw. The water of this river is remarkably soft.

The fourth base-load plant indicated is on the Tennessee River, some miles above Chattanooga. This location would require the construction of a railroad approximately four miles long, extending from the base of the Soddy coal field. This would give the plant excellent railroad connection with both the Alabama and the contiguous Tennessee coal fields. It is interesting to note that one of the mines of the Soddy coal field, in the early period of its development, retained the transportation rights to the Tennessee River, with the intention of sometime using that stream as a transportation outlet. The size of this plant, as determined by the minimum cooling-water capacity of the Tennessee River, could of course mount into the millions of horsepower.

The fifth base-load plant site is at Hales Bar on the Tennessee River. Here a 20,000-kw. plant is already under construction near the Hales Bar dam. This site differs somewhat from those that have been suggested in that it will receive its coal supply by barge from several coal mines located on the Tennessee River near the Hales Bar location.

Quite probably the future power demand of Chattanooga will absorb a large portion of the power that might be produced in these nearby base-load plants—that is, if Chattanooga outdistances Pittsburgh as an industrial center!

The sixth steam plant indicated is the Gorgas plant already operating on the Warrior River. This 80,000-kw. plant is in the heart of the Warrior coal field. With the stream flow of the Warrior River available for condensing, this plant could be increased to much greater capacity.

On the opposite edge of the Birmingham district another base-load plant, indicated as No. 7, might well be placed near Helena, on the Cahaba River. Transportation lines come from both the north and the south through the Cahaba coal fields near this location. The minimum flow of the Cahaba River will probably limit the capacity of this plant to 20,000 kw.

The question is often asked why it is necessary to install such large central stations when a distribution of coal and of condensing water is more favorable to small plants. Aside from the much greater overhead cost of operating many small plants, we must consider the expense of connecting these small plants into a high-tension transmission system. The installation costs of the equipment for connecting in these stations (transformers, switches and lightning arresters) is so great per kilowatt of installed capacity as to be prohibitive. Fig. 6 shows the cost per kilovolt-ampere of transformers, switches, and arresters required to connect into a 110,000-volt transmission system. For capacities below 15,000 kw. these costs are very high.

By comparison of the curves of Figs. 6 and 7, the latter showing the costs of small turbo-generator stations, in this district it is seen that the unit costs of the small-plant switching and transforming equipment reach prohibitive figures.

The large base-load plant, stragetically located with respect to fuel, water, and transmission systems, will be a vital factor in the superpower system of the future.

The Labor of the Region

We turn now to the third division of our subject—man power. As pointed out in the able lectures on Southern History by Dr. S. C. Mitchell, professor of history in the University of Richmond, the greatest economic result of the Civil War was not the setting free of the negro, but the recognition and freedom offered the white people of the mountain sections. The Southern Appalachian

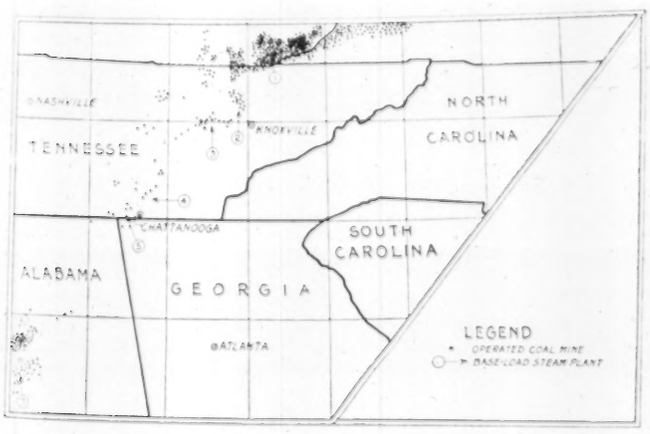

FIG. 5 MAP SHOWING DISTRIBUTION OF OPERATIVE COAL MINES IN THE SOUTHERN APPALACHIAN REGION, AND DESIRABLE LOCATIONS FOR BASE-LOAD STEAM PLANTS

(Sites: 1, Pineville; 2, Clinton-Coal Creek; 3, Harriman; 4, Chattanooga; 5, Hales Bar; 6, Gorgas; 7, Helena.)

Mountains were peopled by an English, Scotch, and Irish stock that had taken to the mountains and hills, in refuge, apart from the cotton plantations. These people could not economically compete with the slave labor of the southern planters, of the plains. Rather than degrade themselves to practically peon existence in such competition, they moved to the mountain sections to earn a meager living on small tracts of tillable land.

In general characteristics these people differ widely from those of the plains. The very nature of the slave system made manual labor for the white people of the plains disgraceful according to their social thinking. On the other hand, for the mountain people manual labor was essential to existence. It was necessary for every one to work, and work was recognized as an integral part of their social community life.

In physical characteristics the mountain people differ from the lowlanders in that the higher altitude and lower average temperatures have permitted them to move faster. This together with the greater physical ruggedness necessary to cultivate and travel the mountain slopes has given them a great advantage over their

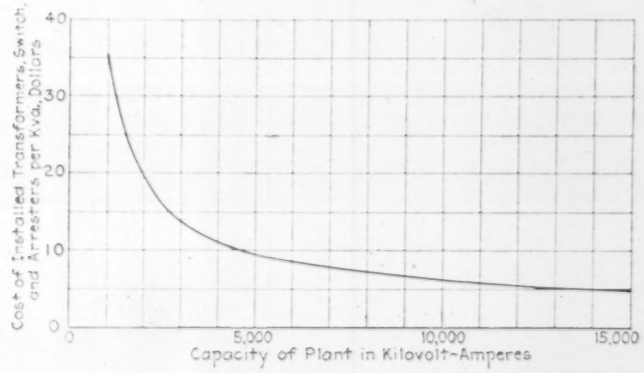

FIG. 6 COST OF CONNECTING SMALL GENERATING STATIONS INTO A 110,000-VOLT TRANSMISSION SYSTEM

FIG. 7 COST OF INSTALLING SMALL BASE-LOAD TURBO-GENERATOR STATIONS

brothers of the plains. The greatest handicap that the mountain folk have experienced in their physical development has been the vicious attack of the hookworm. While in many sections today this is entirely under control, yet the inroads made will be in evidence at least for another generation.

To this mountain stock that was so carefully preserved through the slave period, the South owes much of its present industrial development. The freeing of the slaves produced on the plains, a chaotic condition. The colored man was enjoying a new freedom which he did not know how to use. The plantation owners were helpless in that their fortunes were depleted and they had been trained to look upon labor as degrading. Thus, the men to save the situation were these sturdy mountaineers. They knew the South, they knew how to work, and they knew how to exist on a very meager food supply. In many of their homes the staple food for years had been the "three m's"—meat, meal, and molasses; thus they were inured to hardship.

It is this same stock today that is the potent factor in the industrial development of the South. It is the source of supply of some of the best labor and brains in America. While a textile mill in the very midst of the cotton-plantation areas is frequently in distress, in the mountain towns and those cities drawing their labor supply from the mountain areas the looms have been spinning prosperously for the past decade, with every evidence that within the next few years the textile-mill Mecca of America will be the Southern Appalachian slopes.

A study of Fig. 8 will reveal graphically the race composition of these mountain slopes. The basic data for this map were taken from the 1920 United States Census. Several counties within the

area covered by this study have less than one colored person per thousand inhabitants. Within these counties the face of a colored man is less commonly seen than in most of the industrial centers of the North.

The relatively small colored population of these mountain counties is not the only remarkable condition, for the percentage of foreign-born population is still lower. The foreign-born populations of North Carolina, South Carolina, Georgia, Alabama, and Tennessee are all less than one per cent. This can be more fully appreciated by comparison with Pennsylvania with its 15.9 per cent, New York with its 26.8 per cent and Wisconsin with its 17½ per cent foreign-born population.

In the seven states included as a whole or in part in this study, viz., Alabama, Georgia, North Carolina, South Carolina, Kentucky,

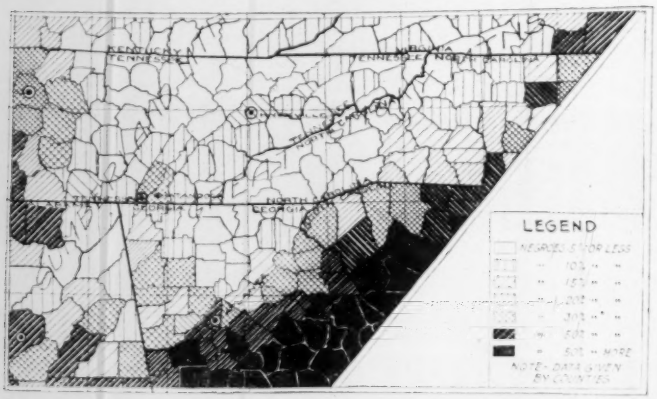

FIG. 8 RELATIVE DENSITIES OF WHITE AND BLACK POPULATION IN THE SOUTHERN APPALACHIAN REGION

Virginia, and Tennessee, an area whose total population is over fifteen million people, there are only 124,391 foreign-born inhabitants. When we compare this with the smallest state of the Union, Rhode Island, having a total population of only 604,397 according to the 1920 census, of which 173,499 were foreign born, the contrast is striking.

With the enforced restriction on labor immigration to American shores, the home supply of workers and of employment is being more closely surveyed. The assembling in large industrial cities of large aggregations of workingmen living under unhomelike surroundings has never solved any of our labor troubles, but on the contrary has engendered a host of disturbances.

While in many industrial centers this condition has been growing worse and worse, a far different system has set itself up in the southern districts. Briefly, the mills are locating near the homes of the workers in the small towns and cities instead of in the large industrial centers. For decades men have located large manufacturing plants in large cities with a beckoning finger to the working man or the working woman to leave the home surroundings and come to them. The result has been overcrowded cities, with employees forced to adjust themselves to unhappy conditions of both living and working.

Today over the Southern Appalachian slopes we find hundreds of small manufacturing plants locating in the small cities. These mills are not seeking alone cheap power and cheap transportation. The greater consideration is a reliable and contented labor supply. These plants are being located where the adjustment of the home life is but a matter of turning one's footsteps in the direction of the new mill where the income in dollars and cents is higher than that to which one has been accustomed.

The new mill soon becomes a recognized home industry. With enlightened management, the life and interest of the worker are soon closely associated with that of the organization and he thinks of it as a part of his home—and of himself as constituting really a part of the organization.

A survey of these plants will show that labor disturbances are rare. There are sufficient duties in the long-established home, in the church, and in the town to occupy the free moments of the workers. The likelihood of assembling for other than very real grievances is remote. Occasionally some difficulty arises from the activities of over-zealous local politicians, but usually such activity soon loses its color and influence. The professional labor agitator has not become acclimated to this region.

On the eastern slopes of the Appalachians this movement of the mill to the labor has been the most marked. In some counties of the Carolinas the mill saturation point has about been reached. Like all similar movements, it is traveling from east to west. On the Southwestern Appalachian slopes the movement is still in its infancy. There still exists within the region outlined a great reservoir of American-born labor that for many industries will provide the solution of the labor problem for many years to come. And the value of this labor supply will become better appreciated as the regulations dealing with foreign immigration become more stringent.

The reaction of this industrial growth upon the social life of the worker himself is markedly beneficial. The elimination of the hook-worm disease, the introduction of better community sanitation, and the inevitable relegation of the senseless family feud to the scrapheap of ancient customs will all lift from the mountain folk a burden of hardship the depressing effect of which they themselves have not recognized. The responsiveness of these people to the higher social standards of the more enlightened environment into which they come when some of them move down into the larger cities of the region is an outstanding characteristic.

In the preparation of this paper its authors have intended to exercise due restraint. It has been their thought rather to suggest the industrial possibilities of the section than to paint them in glowing colors. If the paper shall contribute in a slight degree toward a broader knowledge of the Southern Appalachian mountain region, its purpose will be met.

Labor Versus Mechanical Power

ACCORDING to figures recently issued by the United States Bureau of Immigration, less stringent immigration laws will not solve our labor problems. During the year ended June 30 last, immigrant aliens to the number of over 500,000 entered this country. Only about 80,000 of these were laborers as against over 100,000 skilled workmen and nearly 200,000 women and children without any occupation. This ratio is not unusually low, but about the average. As long as this condition exists, anything that may be done to remedy a shortage in common labor by releasing the restriction against aliens entering this country will aggravate the situation rather than help to solve the problem, on account of the large number of unsought-for persons entering at the same time.

A solution of the future labor problems is not to be found in more labor, but in less labor and a greater use of mechanical power. Great advancements have already been made in this direction, but a great deal more has to be done.

In this country higher wages are paid than in any other country of the world—in some cases two or three times those paid in foreign countries—yet American industry can compete in the markets of the world. This has resulted from the use of power, making it possible for one worker to produce with a machine what required several to do by hand. In 1869 an average of six-tenths horsepower was used in this country per wage earner; by 1919 this figure had increased to over three and one-quarter horsepower, which follows along a similar line as the average increase in wages during this period.

Although the use of more efficient methods in industry is primarily in the hands of the management, nevertheless labor has its responsibility. If labor is going to continue to demand a higher wage for its services, it must expect to coöperate to make its efforts more productive. Estimates show that there are over two hundred thousand more miners in the coal industry than required to produce the country's coal. This is with present methods; if modern methods were generally introduced in the coal-mining industry, this figure would be greatly increased. The coal industry is one of the worst offenders, but it is by no means the only one responsible for labor wastes in industry. Until such wastes are eliminated it will be difficult to see where more labor is required.—*Power*, vol. 58, no. 13, Sept. 25, 1923, p. 563.

The Chemical Warfare Service—Its Activities and Achievements

THE Chemical Warfare Service represents the most advanced application of science and engineering to military purposes. Its activities are those of scientific and technical warfare in its highest phase. Undoubtedly its already recognized effectiveness is due to the fact that it has applied processes and methods to military purposes which have already brought about revolutionary results in civil life in peace times.

Chemical warfare is a very recent development, its first effective employment having been on the memorable morning in April, 1915, when the Germans discharged a cloud of chlorine against the Canadians in the Ypres section. From that crude beginning in less than ten years a comprehensive and effective service has developed which now comprises among its functions not only the use of gases but also the provision of means for the detection of and protection against gases, the use of smoke screens, signaling means, and inflammable materials, and many auxiliary features.

The ancient discovery of the bow was the first rude application of engineering to warfare, requiring as it did a considerable amount of thought and knowledge in the selection of proper materials for the bow itself, the bow string, and the arrow. Thousands of years later chemistry revolutionized the methods of armed conflict by the invention of powder. From then on progress was rapid, resulting finally in the evolution of the present high-speed automatic rifle and rapid-fire gun on one hand, and the immense and complicated artillery guns on the other.

In one way, however, the rifle and gun were merely outgrowths of the bow. Just as the bow shot out an arrow which had to reach its human mark in order to be effective, so the rifle and gun threw a bullet or shell. The range and force of penetration were tremendously increased, but the mode of action remained essentially the same.

To some extent shrapnel and high-explosive shells departed from the old bow-and-arrow principle in that they made it possible to create a small "area of destruction." This area, however, remained extremely small and furthermore had only what might be called a momentary effectiveness, only those being endangered who happened to be within the area when the explosion took place.

The New Element in Warfare: The Gas Attack

Chemical methods of warfare in their use of gases [this term is used here merely because it has become familiar to the public; actually, however, the majority of gases used in warfare are not gases at all, but either liquids or solids which are atomized or scattered by the booster charge of the shell] have brought a new element into combat. In the first place, they have made it possible to attack extensive areas—whole square miles today, and possibly hundreds of square miles within the next few years. In the second place, the new method of warfare provides for attacks which are not merely momentary in their duration as are those by shrapnel or high-explosive shells, but which extend over considerable periods of time. Thus, a trench properly sprinkled with mustard gas would be dangerous to stay in even after several days. In the third place, a "timed" attack becomes possible, and in fact was used in at least one instance in the last war. A section of a battlefield can be covered by shells timed to explode several hours after they fall on the ground. Such a region would become dangerous only after these shells had exploded and had discharged their lethal contents. This is somewhat like the timed-fuse mine of an earlier day but vastly easier to handle and more efficient.

The most significant thing about the Chemical Warfare Service is the spirit in which the work is carried on. For example, at Edgewood Arsenal, which is its research and manufacturing headquarters, practically the entire research personnel are civilians, though the executive staff consists of commissioned officers. The men who are developing the gas and gas protection, smoke screens, etc., know nothing of Clausewitz and Vauban and are even ignorant of the most elementary principles of drill, but they understand everything about chemical valences and modern factory production methods. They are not soldiers at all but merely engineers, scientists, and chemists engaged in developing the best methods of efficiently killing one set of human beings and protecting another set from being killed, and are applying to their work the same methods, practices, and devices that have proved their efficiency in the manufacture of shoes, rails, and typewriters. Those who still talk about the romance of war would have a rude awakening were they to go through the laboratories of Edgewood Arsenal and see how this romance of warfare is being prepared in the test tubes of organic chemistry.

Early Work of the Chemical Warfare Service

When the Chemical Warfare Service first set about its work, in the summer of 1917, our knowledge of gases used in warfare was very limited and it was thought that complex mixtures consisting of three, four, or perhaps five materials might have to be used as fillers for shells. Because of this an elaborate mixing apparatus was installed consisting of a system of piping leading from various supply tanks of materials. These pipes led to five-way valves, Fig. 1, which could be operated from the outside of the mixing building, so that the leakage of the poison material would not affect the operator. The latter likewise from the outside of the building could see the temperature of each of the materials and the amount of material which filled the mixing tank.

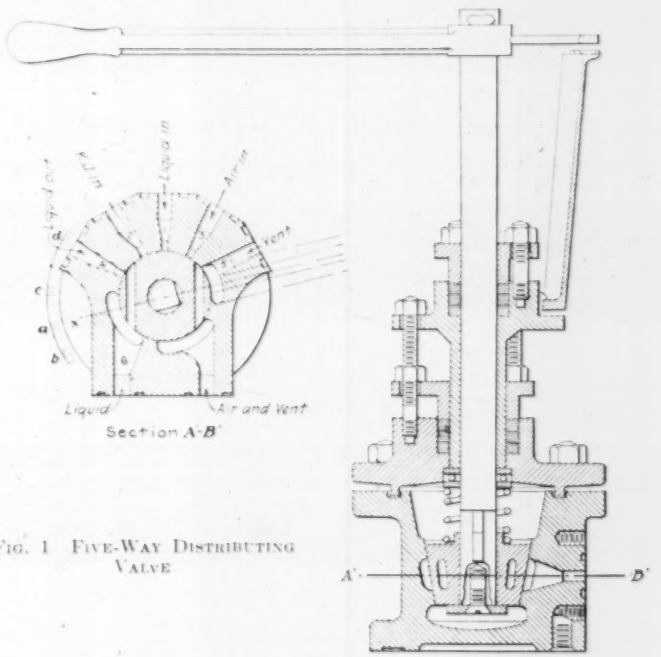

Fig. 1 Five-Way Distributing Valve

These mixing outfits are remarkable for the ingenuity of their design and the success with which the difficult and dangerous problem has been solved with comparatively simple means. It was found later, however, that all this work had been entirely unnecessary, as in actual practice materials such as phosgene and mustard gas proved to be far superior not only from the point of view of manufacture of shells but also because of their casualty-producing effect as compared with that of the originally projected complex mixtures.

Edgewood Arsenal as it stands today still embodies the basic idea with which it was developed, namely, that of attaining a maximum production within the shortest period of time, so as to relieve the hard-pressed armies of England, France, and Belgium on the western front in 1918. Much makeshift machinery still remains. The engineers of the arsenal realize that better machinery could have been designed and undoubtedly know how to do it,

FIG. 2 PLANT AT EDGEWOOD ARSENAL FOR FILLING SHELLS WITH PHOSGENE

but in those days it was not the most efficient but the easiest available machinery that had to be selected. Nevertheless it does the work, and that is the most important thing.

SHELL-FILLING MACHINERY AT EDGEWOOD ARSENAL

From this point of view the shell-filling machinery is of great interest. There are two types of it installed—one of the constant-level type used for filling shells with phosgene, and the other of constant-volume type for filling shells with lachrymators.

In the phosgene-shell filling plant the first problem is to chill the phosgene to the point where it will not evaporate. This is necessary in order to permit the workmen to handle the machinery without gas masks, thus increasing the efficiency of work many times and also providing for greater safety of the men. The phosgene containers from the generating plant are made to pass through a long room kept at a low temperature by means of ammonia coils. From these the phosgene is discharged into tanks having six spring-controlled outlets (Fig. 2). The level of the liquids in the tanks is maintained constant by means of flood-control valves. Six shells at a time are brought by a chain traveler into proper position below the outlets referred to above. The operator then pulls a lever which lifts the shells and presses their necks against a spring-controlled collar. This opens a valve and permits the liquid to flow until it reaches the same level in the shell that it has in the tank, which is equivalent to the proper charge of phosgene for the given type of shell. After a little practice the operators know exactly how long to keep the shell against the collar in order to have it completely filled. From the filling station the shell travels to the next position where the booster is screwed into it, and then goes to the inspection department, after which it is ready to be shipped to the battle front.

The constant-level type of apparatus has the disadvantage that it has to employ several valves of comparatively small size. This disadvantage becomes serious when the filling liquid is of a highly corrosive nature, in which case the constant-volume type has to be used (Fig. 3). This kind of machinery is essentially somewhat similar to the gasoline pumps used for filling automobiles. A given amount of liquid is discharged into a container just sufficient to fill one shell. When the container is full, the shell is pressed against an outlet with a spring-controlled valve and the liquid is transferred to the shell. Those who enter the constant-volume shell-filling plant have a good illustration of the truth of General Sherman's famous saying as applied to modern warfare. While no shell filling has been done in the plant for over two years, the walls are nevertheless so permeated with the vapors of the lachrymators that escaped into the atmosphere when work was being carried on, that it is impossible to remain inside for more than a couple of minutes without having the eyes smart and water.

Because of this condition and also of the impossibility of preventing some escape of the shell-filling material into the atmosphere, great care has been paid to the ventilation of the buildings containing the shell-filling plants. The phosgene-shell-filling plant is equipped with a powerful double ventilation system, in addition to which as a reminder of the character of the work being done there, a row of masks are hanging on the walls within easy reach of the men.

OTHER WORK CARRIED ON AT EDGEWOOD ARSENAL

At Edgewood Arsenal it is no unusual thing to encounter familiar equipment used for novel purposes. Thus, there is a battery of gas producers. These are used for making carbon monoxide, which, in its turn, is further converted into phosgene. The gas producers are supplied with a mixture of carbon dioxide and oxygen and are said to operate under these conditions with perfect reliability and great efficiency. Because of the character of its work, which of necessity must be highly confidential in many of its phases, and also because of its location in practically open country, the Edgewood Arsenal has to rely largely on its own resources. It is magnificently equipped to do so, having a power plant of its own, a large refrigerating plant, splendid chemical and physical laboratories, and in addition an extensive and well-equipped machine shop.

In connection with the latter, there are one or two features which deserve special mention. It is no unusual thing for some of the men to have to work nights or Sundays in order to complete a piece of machinery needed for some research work or a rush repair job. In order to secure greater convenience in this kind of work when but one or two men have to remain in the shop alone, an emergency bay has been arranged in which the most important machine tools are grouped together in such a manner that one man can take care of two or three simultaneously. The same rather unusual care and thoughtfulness is evidenced in other directions. A small but significant indication of it is shown in the handling of reamers. What every one should realize but many do not is that the reamer is really a delicate tool and should be handled with about the same care as a razor. It is the rough handling of reamers that dulls them much more than the actual cutting. At the Edgewood Arsenal every reamer when it is returned to the tool room is inserted in a thick paper tube which protects it from scratching against the case and from the action of the atmosphere. It is claimed that reamers last twice as long with this arrangement as they would without it.

AN OUTDOOR ANEMOMETER

The true character of the Edgewood Arsenal work and what it stands for does not become apparent until one reaches the departments of physics and chemistry. As an illustration of what is being done there, Dr. T. B. Hine's department of field work may be mentioned. The great importance of smoke screens in warfare is now unquestioned, but the persistence and spread of smoke screens depend on the character of the atmosphere into which they are projected. It becomes important to the modern soldier to know the state of the atmosphere. The old bowman also had to know it, but as the precision of his knowledge could not be very exact, he accomplished his purpose by wetting the finger and sticking it up in the air. The modern scientist-warrior, of which Doctor Hine may be taken as a representative type, is not satisfied with such crude means. He wants to have not only an exact knowledge but a true record of the state of the air with all its eddies, turbulence, and shifts of direction of the wind. To do this an outdoor anemometer has been developed using the same principle as that proposed by Professor King of Canada, namely, the variation in temperature of a hot wire exposed to the air. The apparatus has not yet reached its final stage of perfection, however, and while it does give the

desired information, it is somewhat clumsy to handle in open country. A type is being developed which promises to satisfy the conditions of portability as well as that of precision.

A New Gas-Sampling and Analytical Method in Use at Edgewood Arsenal[1]

A new method of sampling and determining very small quantities of foreign gases in air has been developed and is in use at Edgewood Arsenal for field experimentation. This method has proved so useful in this work that it may be of value in the control of certain industrial waste gases or studies of atmospheric pollution by industrial plants. The method consists of two essential parts: (1) A portable machine for drawing and measuring large samples of air; (2) A special charcoal cartridge to absorb the foreign gas from the air sample and a laboratory analytical method of determining the quantity of foreign gas absorbed in the charcoal. The analytical method consists of combustion of the charcoal, absorption of part of the gases of combustion in a suitable solution, and determination of the quantity of a certain element characteristic of the foreign gas, using ordinary analytical methods. In the field work at Edgwood Arsenal many of the gases to be determined contain chlorine, hence this element is the one determined in the gases from the combustion of the charcoal. The method can obviously only be applied in case the foreign gas to be determined in air contains some element other than hydrogen, oxygen, nitrogen, and carbon, but this still leaves a large field of possible application including such substances especially as the sulphur dioxide or sulphuric acid fumes from smelters and many chemical industrial waste gases.

If we wish to determine very small quantities of foreign gases in the atmosphere it is necessary to take quite large samples, and it is desirable to be able to adjust the size of sample somewhat to the concentration of the foreign gas. The use of evacuated flasks or water aspirating bottles which are often used for gas sampling become very clumsy if not impossible when large samples and portability are desired. The apparatus for drawing a number of large samples as used in the field experimentation at Edgewood Arsenal is shown in Fig. 4.

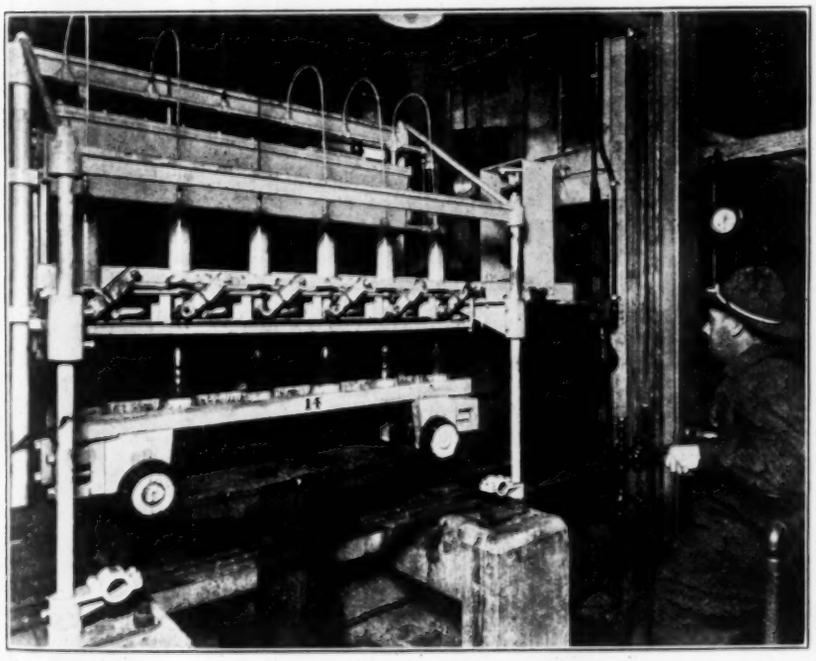

FIG. 3 FILLING MUSTARD-GAS SHELLS

When the sampling machine is in action an air pump driven by an electric motor draws six samples of air simultaneously through six calibrated flow meters at the rate of 20 liters per minute. The charcoal absorption cartridges or other absorption apparatus which may be in use are at the end of long rubber tubes which allow the samples to be drawn from any desired points within a reasonable radius of the sampling machine. The rate of flow of the gas is adjusted to allow for the different resistances of the individual absorption cartridges by means of the needle valves on the front of the machine. A further adjustment, which, however, is not always necessary, is provided in the shape of an opening from the suction side of the flow meters to the atmosphere which is controlled either by a needle valve or by bubbling the air through a constant head of water. The water bubbling flask is disconnected in Fig. 4.

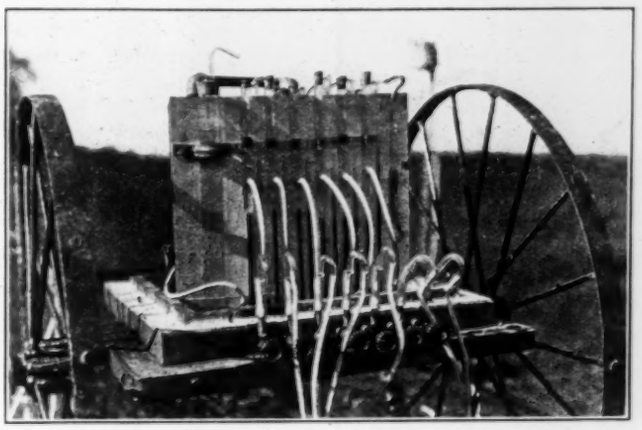

FIG. 4 APPARATUS FOR RAPID AIR ANALYSIS
(The air under examination is passed through tubes containing activated charcoal which absorbs certain impurities.)

Since the flow meters are calibrated at one definite pressure and are run at various pressures due to the varying resistance of the absorption cartridges and connecting tubing, it is necessary to measure the pressure on the suction side of the flow meters while the sample is being taken in order that the true volume of the sample at atmospheric pressure may be calculated. This pressure is measured by a mercury manometer. It should perhaps be mentioned that the 1-hp. motor employed is much larger than required to drive the pump and was only used since this was the smallest 220-volt d.c. type available in sufficient numbers at the arsenal when these machines were built. The power to drive the motors on a number of these machines is supplied by a portable generator driven by a gasoline motor.

A number of liquid absorbents in different forms of apparatus were tried before the charcoal cartridge was developed, but none of these were completely successful in removing minute traces of chemically rather inactive gases from air. Ordinary activated charcoal such as is used in gas masks was found to remove the gases from the air, but all attempts to determine the amount of them in the charcoal were unsuccessful. Finally a special charcoal was made which was essentially free from chlorine and gave no ash when burned. With this charcoal entirely satisfactory results have been obtained when analyzing air containing chlorpicrin or mustard gas.

A satisfactory activated charcoal free from ash and chloride can doubtless be made in a number of ways, but the exact procedure found to give a satisfactory product is here given in detail:

Mix thoroughly 485 g. of light cylinder oil with 120 g. of lampblack, both tested to assure freedom from chlorides, transfer the resultant paste to an iron retort provided with a vent, and heat the retort in four hours from room temperature to 800 deg. cent. Hold the temperature at this point for 20 hr. At the end of this time the retort is cooled and the charcoal is passed through a 10-mesh sieve and caught on a 16-mesh sieve. All material passing the 16-mesh sieve is rejected as fines. The remainder of the charcoal is now ready for activation.

Since the finished charcoal must be as free from chlorine as possible, extreme care must be exercised to prevent contamination of the charcoal, both during and after activation. The activation is carried out in a $\frac{3}{4}$-in.

[1] This description of the method has been kindly contributed by Dr. T. B. Hine. The laboratory work on the method was mainly carried out by A. H. Huisken and A. M. Rowe, working under the direction of Dr. Hine.

silica tube heated in a vertical tube furnace. The bottom of the tube is loosely stoppered with asbestos fiber and the top is connected with a distilling flask in which steam is generated from distilled water. To activate the charcoal, fill the tube to the height which the furnace will heat and place it in the furnace, which has been previously heated to 875 deg. cent. Pass steam through the charcoal for 35 min. Water gas is formed at this temperature and the time should be measured from the first appearance of water gas. This may be detected by testing the exit gases for combustibility. After the steam treatment has continued for 35 min. disconnect the steam and heat the charcoal for 5 min. to remove residual moisture. Empty the contents of the tube into a Pyrex flask before it cools, stopper the flask tightly, and cool. This charcoal will be found suitable for use.

Charcoal prepared in this way contains about 0.001 per cent of chlorine as shown by the combustion of a series of 5-gram cartridges. This charcoal will absorb about 10 per cent of its own weight of chlorpicrin before letting any detectable amount through, and this is a hundred times the amount required in a sample for accurate analysis. The charcoal cartridge used in field work contained 5 grams of the special charcoal supported on a little

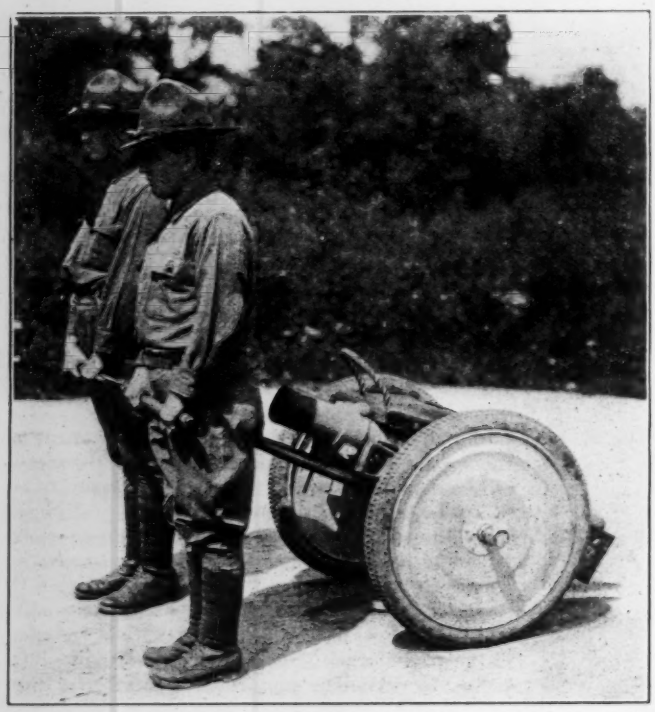

Fig. 5 One Type of Cart Developed for Transporting a Stokes Mortar

glass wool at the constricted base of a glass tube about 1 cm. in diameter.

The combustion of the charcoal is carried out in alundum boats in a silica tube using oxygen and an electric combustion furnace. A section of the silica tube in the furnace beyond the sample boats is filled with silica chips previously very carefully cleaned by boiling with hydrochloric acid and washing free from chlorides. These chips assure the complete breakdown of any organic compounds that might otherwise be distilled out of the tube without combustion. The gases of combustion are scrubbed in tall absorption towers filled with glass beads and, when chlorine and hydrochloric acid are to be caught, containing a solution of sodium sulphite and bicarbonate. The chlorine content of this scrubbing solution is determined either volumetrically or gravimetrically by well-known methods. Since the chemicals used in scrubbing and analysis are difficult to obtain wholly free from chlorides, a blank is first run and this chlorine content subtracted from the results of each analysis.

The percentage accuracy of the method depends upon the quantity of the foreign gas absorbed in the charcoal. If the quantity of absorbed gas is not much below the equivalent of 10 milligrams of chlorpicrin, it can be determined within about 1 per cent. In actual field work when large numbers of samples are taken and analyzed it is found that samples taken at the same place and time will not always check quite this closely. When drawing samples of about 100 liters it was found that duplicate samples when containing 10 milligrams or over checked within about 3 per cent, when containing 5 milligrams or over, within about 6 per cent, and when containing 1 milligram, within about 15 per cent. This may not at first sight appear to indicate much accuracy, but when we consider the minute concentrations in the air which we are determining, the accuracy appears remarkably high. A concentration of 10 milligrams of chlorpicrin in 100 liters means about 0.0015 per cent by volume or 15 parts per million, while the 1 milligram which can be determined within about 15 per cent represents in this case a concentration of only 0.00015 per cent by volume or 1.5 parts per million parts of air. This represents an accuracy of analysis which at least to our knowledge has never been attained before in the routine analysis of a large number of samples.

Solving the Problem of Spraying Liquids from Airplanes

One of the most recent developments promising important results from both a military and a civilian standpoint deals with airplane sprays. There have been many attempts to spray liquids from airplanes, none of them, however, being successful. It is obvious that if liquids could be sprayed in such a way as to reach the ground without excessive loss, important results could be achieved. Thus, for example, if in war time an area could be properly covered by a fine rain of mustard gas, it could be made uninhabitable for a considerable period of time. On the other hand, in peace time equally desirable results might be achieved by the application of calcium arsenate to a cotton field infected with the boll weevil. It appears that hitherto whenever this has been attempted the liquid would mysteriously disappear in the air without reaching the ground. Dr. Hine, however, has solved the problem.

From previous investigations, in particular those of Leonard, it would appear that a drop of liquid falling from a great height, such as from the clouds, at first accelerates in accordance with the general law of the earth's gravitational field. In doing so it encounters a resistance on the part of the air which increases in a certain ratio with the speed, and this resistance tends to retard the drop on one hand and decrease its size on the other. It would appear that for water a drop reaches a state of equilibrium at a diameter of 4 mm. (slightly under $^1/_6$ in.), which means that at this diameter the drop falls at a constant speed and retains its size and shape. This is one of the reasons why raindrops are so uniform in size and why extremely large drops come only from very low-lying storm clouds.

Were it possible for an airplane to remain stationary when liquid was being sprayed from it, the drops in falling would break up in exactly the same way as do raindrops, would reach a standard size of 4 mm. diameter for water and diameters for other liquids corresponding to their viscosity and specific gravity, and would ultimately reach the ground. As a matter of fact they do not, which is due to the fact that as the liquid is sprayed from an airplane it is picked up by the powerful air stream coming from the propeller and immediately broken into a mist which naturally has no means of reassociating into larger drops and hence does not fall on the ground as a spray.

What Dr. Hine did was to discharge the liquid under pressure from a hose located in such a manner and at such a distance from the main body of the airplane that the spray was initially delivered into a comparatively quiet stratum of air. As a result of his work, means have been found to deliver a spray not only without excessive loss but in such a manner as to cover definite areas of ground. Thus, at a recent demonstration at Edgewood Arsenal, the officers of the War and Navy Departments were sprayed from an airplane with perfumed water.

Development of a Portable Trench Mortar

One of the interesting things which "may be told now" deals with the development of a portable type of Stokes mortar. The original, mortar, an English invention, proved for all its simplicity one of the most useful tools of trench warfare. Essentially, the Stokes mortar is merely a tube closed at the bottom. A shell

(Continued on page 669)

Modern Subway Cars and Their Operation

As Exemplified on the City Owned Rapid-Transit Lines in New York

By SELBY HAAR,[1] NEW YORK, N. Y.

THE subject for consideration at this session is really the steel passenger car; on account of the breadth of the theme, however, the author will confine his remarks to steel cars in New York City, and particularly in the city-owned subways. The paper has purposely been made brief, to permit full discussion in order to record, before it is too late, the early history and the influences which molded the development of a piece of apparatus which all but monopolizes its field, and which now engages millions of dollars of invested capital, calls for the employment of tens of thousands of skilled workmen, and is turned out by the thousands every year—all of which has grown up in the twenty years since a sample car was built for the New York subway at the Altoona shops of the Pennsylvania Railroad Company. An invitation is extended at the outset for the contribution of all pertinent information on the subject, particularly reminiscences of the early days.

The successful operation of the New York Subway and all modern passenger subways was made possible by:

1 The electric system of power generation, transmission, distribution, and application to trains, particularly the multiple-unit system of motor control

2 The block-signal system of train control with high track capacity; and

3 Last but not least, the steel car.

There is room for argument that (1) may be divided into several items, but for the present paper such subdivision is unnecessary. The selection of these features was made with two points of view in mind, economics and safety.

Nowadays it may scarcely be believed that there was grave doubt among many unbiased students of the New York transportation problem 25 years ago that the subway would earn a profit, and hence the present generation are amazed to hear of the risks that the contractor took who signed the first Interborough subway construction and operating contract in 1900. Economic necessity dictated that the power system should be of high efficiency, that the length of trains should be capable of increase as much as was warranted, that the construction and maintenance costs of the cars should not be much, if any, greater than such costs for wooden cars, and that the signal system should permit the safe operation of trains at headways closer than had been before attempted. How successfully these requirements were met is a matter of common knowledge.

Time does not permit a discussion of the electric power system and the signal system from the safety standpoint, any more than to say that they have met all expectations fully. The author, however, must call attention to one important feature of the signal system, namely the automatic track trip, which is lowered when the block with which it is associated is free of trains, and is raised when the block is occupied. If a train passes over a raised track trip, an air valve on the truck and connected to the air-brake system is struck and opened, causing an emergency application of the brakes; thus a train already in a given block is protected from a rear-end collision. This feature is essential to permit the short headways that are scheduled.

The steel car was produced by Mr. George Gibbs, consulting engineer to the Interborough Rapid Transit Company, to eliminate fire hazard from subway operation, for which purpose it has been a success. The author is informed that at least one all-metal railway car was built many years ago, but subway limitations of size, weight, and manufacturing cost compelled the development of an entirely original design. Attempts had been made to produce car bodies that would not burn by building them of asbestos in molded and board forms, and also by searching for a method of fireproofing wood, but the steel car was recognized as the real answer to the problem. To assist in gaging the seriousness of the danger, consider the following facts: A fire in one train would threaten a large number of people, 1000 to 1200 in 1903, 1600 to 2000 at the present time. A fully loaded express train draws momentarily from the power system every time it starts from rest, that is, every few minutes, 4000 kw. (approximately 5300 hp.), which is nearly twice the (horsepower) capacity of the most powerful steam locomotive in this country. The power system which is adequate to meet such demand is of such enormous capacity that a dead short-circuit under a car might easily amount to 100,000 amperes, which at 600 volts would be 60,000 kw. A current of that magnitude would produce such intense heat in a fraction of a second as to consume utterly any wood near it, not to mention the explosive effect of the sudden heating of air and moisture in the confined space of a subway tunnel. It is to be noted that not only is the car body constructed of incombustible materials (with a few exceptions), but, furthermore, the steel is an electrical conductor which forms a part of the power circuit (grounded side), so that any failure of insulation which might cause a fire is converted promptly into a short-circuit, and the power supply disconnected directly. The lower the resistance of a short-circuit, the more quickly the safety devices act. Not only is the insulation of the electrical conductors composed as far as possible of incombustible materials, but, in addition, the type of motor control and other apparatus has been improved and the arrangement of parts on the car changed until the risk to the patrons of the subways of injury by fire is vanishingly small.

As the general adoption of an idea is good evidence of its merit, it is gratifying to note that both the block-signal train-control system and the steel car, which were developed on the Interborough subway, are steadily being introduced on our trunk-line steam railroads.

In spite of the fact that modern subway cars are covered with detail apparatus, much of which is of an intricate nature, yet as each part is designed for the greatest reliability, the detentions due to equipment failures are astonishingly small and few. The author hopes that there will be contributed at this time some data of that kind, also of maintenance costs, depreciation, etc. It is interesting to note that some of the first Interborough cars, which are nearly 20 years old, are apparently good, from the physical standpoint, for many more years of life.

City-Owned Rapid-Transit Lines in New York

The municipally owned rapid-transit lines of The City of New York are divided, for purposes of operation, into two groups, generally known as Interborough and New York Rapid Transit (also known at various times as Brooklyn Rapid Transit, New York Consolidated, New York Municipal Railway Corporation, and Brooklyn-Manhattan Transit Corporation). The Interborough system of lines (Subway Division) was constructed under three contracts: No. 1, dated February 21, 1900, No. 2, dated July 21, 1902, and No. 3, dated March 19, 1913. The New York Rapid Transit system of subways, together with some elevated lines, was constructed under a single contract, No. 4, dated March 19, 1913, and is operated in conjunction with elevated lines owned by a predecessor company as a single system; the elevated lines of the Manhattan Railway Company, leased to the Interborough Company, are operated independently of the subway division, except in a few places, where trains of both operate over subway-division tracks under a trackageright agreement. The car equipment furnished under contracts Nos. 1 and 2 is the property of the Interborough Company, and that supplied under contracts Nos. 3 and 4 is owned by the city.

Development of the Car Equipment of the Interborough Rapid Transit Company

The story of the car equipment of the Interborough subway is essentially the history of the subway car. The first cars ordered for this road had bodies of a composite type, that is, wood with steel reinforcing and a sheathing of sheet copper, with asbestos

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[1] Electrical and Mechanical engineer. Mem. A.S.M.E.

Contributed by Railroad Division for presentation at the Annual Meeting, New York, December 3 to 6, 1923, of The American Society of Mechanical Engineers. Slightly Abridged. All papers subject to revision.

around the wiring for fire protection. The general design of the car was that of a standard passenger coach with enclosed platforms. Motor cars equipped with two 200-hp. motors weighed 76,000 lb. without passengers, and trailer cars 51,300 lb. under like conditions. Before these cars were put in service a design was worked out for an all-steel body and a single experimental car constructed. In this design only standard rolled-steel shapes then on the market were used, so that the weight of the finished car was found to be too great, being 79,200 lb. It is still in service, however, as a pay car. Although little time remained before the opening of the subway, the design was revised, and 300 of these cars were ordered. They weighed 76,925 lb. without passengers, equipped as motor cars. The subway began operation with 103 of these steel cars and 502 composite cars. Express trains consisted of 8 cars—5 motor cars and 3 trailer cars; local trains of 5 cars—3 motor cars and 2 trailer cars. All cars had substantially the same overall dimensions as the latest cars, namely, 51 ft. 1/2 in. long over anti-climber bumpers (51 ft. 4 in. coupling length), 8 ft. 10 in. over door-threshold plates, 8 ft. 8 in. wide over the eaves, and 12 ft. 1 3/4 in. high above rail (light). The two motors of the motor cars were mounted on one truck of 80 in. wheel base; the trailer trucks had a wheelbase of 66 in. There were four side doors, one at each corner, so located for convenience of operation by the guard, whose station was between cars; this operation was by mechanical levers which converted a vertical pull or push into a horizontal thrust against the door.

Within a few years after the subway had been put in operation it became congested; one of the measures undertaken after an exhaustive study of possible methods of relief was to add center side doors to the cars. This added an average of 8500 lb. to the weight of a car, but substantially reduced the time at stations for loading and unloading passengers, thereby increasing the train capacity of the stations and the passenger capacity of the subway. These doors were operated by pneumatic door engines, each controlled by a transmission rod extending the whole length of the car with operating handles at the ends, functioning in the same manner as the operating handles for end doors. At this time also the length of the subway-station platforms was increased to suit 10-car express trains (7 motor cars, 3 trailer cars) and 6-car local trains (4 motors, 2 trailers). For those who wish further details of the appearance and dimensions of these cars, a brief bibliography is appended.

In the years 1915 to 1918 the company put into service 800 new steel cars, and also removed all the composite car bodies from the subway, replacing them with steel bodies. (The composite bodies were equipped with new trucks and motors and are in service at present on the Manhattan elevated lines.) These later cars have pneumatic door engines for all side doors. The latest standard motor car weighs 75,500 lb. and the standard trailer 54,000 lb. without passengers. Eighty-three of these cars were specially equipped for operation in the Queensborough (Belmont) tunnels, where the grades are steep, by being provided with two 120-hp. motors per car, it being intended to operate them in trains made up entirely of motor cars. Their weight is 71,800 lb. without passengers. After these changes and additions the subway passenger equipment amounted to 1939 cars, all steel. The rush-hour load is figured at 162 persons per car at 140 lb. each; the total weight of a fully loaded 10-car express train approximates 920,000 lb., and that of a 6-car local train, 550,000 lb. These figures are for the latest type of car, the older cars being heavier.

The general dimensions of the cars, as given above, were fixed in the light of the following limitations:

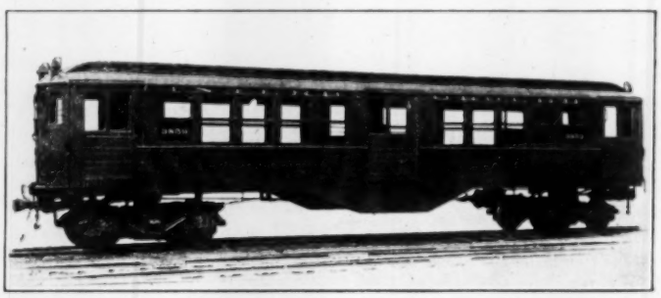
1. Maximum axle load, 30,000 lb.
2. Distance between centers of railroad tracks, 12 ft. 6 in.
3. Maximum height of car above rail, approximately 12 ft.
4. Minimum radius of track curves, 148 ft.
5. Maximum grade 3.1 per cent, except in Queensborough subway tunnels where it is approximately 4.5 per cent
6. Length of station platform: express, 480 ft.; local, 300 ft.
7. Average speed of fully loaded trains between terminal station: express service, 25 miles per hour; local service, 15 miles per hour.

Nearly five years ago, with a view of lowering operating expenses, a scheme of multiple door control was developed to permit a reduction in the number of guards on a train and a shortening of the station stop. The scheme as worked out enables the side doors of an entire train to be controlled by a single guard, although in regular operation one guard is provided for each two cars. The principal changes made in the cars on account of this control were the conversion of the door-engine control from pneumatic to electropneumatic, the introduction of a more sensitive edge or shoe on the doors, and the addition of a considerable amount of wiring and electrical interlocks. These improvements were effected on 982 cars at a cost of nearly $2,000,000. As a result of more than two years' operation of these cars further improvements were developed which are now in course of installation.

Details of the Interborough Company's Latest Car

All of the developments in the Interborough-Company's subway cars are embodied in a group of 100 trailer cars which have just gone into service, and accordingly the following description of these cars may be regarded as representative of the modern subway car.

Body. The body frame is made up of rolled- and pressed-steel members. The floor frame consists of 6-in. I-beams and 6-in. channels, held rigidly in place by liberal cross-braces. Under the center door openings are stiffening girders 26 in. deep. Hedley anti-climbing buffers are fitted at each end. On this underframe is erected a superstructure of pressed-steel side posts and carlines, all carefully braced to insure maximum resistance to shocks caused by bulling or collisions. The end bulkheads also contribute to stiffen the superstructure. The door openings are 4 ft. 2 in. wide, sufficient to allow passengers to pass in and out at the same time. Stanchions of enameled iron pipe located just inside the doors



The Interborough Company's Latest Subway Car

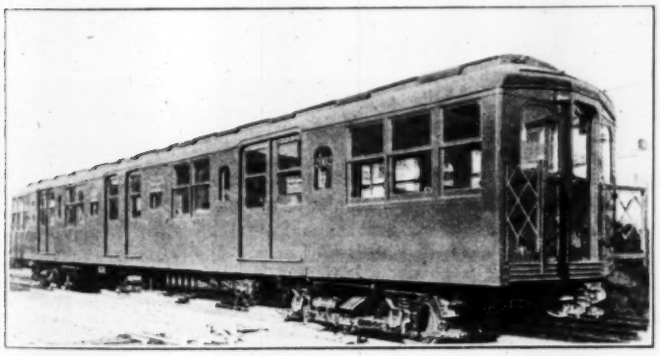
separate and guide the two lines of people. With this arrangement it has been possible to reach an average loading or unloading time of one second per passenger, or less. The roof is of the monitor type with 12 ventilators of the deck sash type per side and is lined with "Agasote," a heat-insulating material. The floor is of 1/2 in. (average) "Flexolith," a light-weight artificial stone. The fixed seats are 44 in number, 18 1/2 in. wide. Hinged seats wide enough for two persons are fitted at the center doors to give increased seating capacity if desired. Fifty-six swinging metal handholds with enameled steel grips are installed in each car. Route and destination signs are painted on metal plates and are mounted inside the windows in iron frames. The draft gear is of the friction type, securely attached to the car body. The air connections between cars for the air-brake system are made automatically by the draft gear. Body bolsters are of the built-up type. The air brakes are of the Westinghouse U-E-5 type, with 25-ft. air compressors. Door engines are of the geared type, of sufficient power to close the doors in about two seconds. They are usually adjusted for a closing time of approximately four seconds. The end doors close an opening about 3 ft. wide; they are opened and closed by hand.

Body Electrical Features. Each car has two systems of lighting, the emergency lighting being distinct from the normal. Energy for the normal lights is collected from the third rail by four shoes, one on each side of each truck. Twenty-five lights are provided in each car, two at each platform and the remainder inside the body in three rows, one along the longitudinal center line of the car and the others over the seats. This arrangement produces a minimum illumination of 3 foot-candles on a plane 3 ft. 6 in. above the car floor with a voltage of 85 per cent of the line voltage. The lamps are 40-watt and are shaded. Two emergency lights are supplied, one at each end bulkhead, which are fed from a 34-volt storage battery of Edison cells. The emergency lights are automatically

thrown into service by a relay upon failure of the normal supply. The battery is charged through the normal lighting system.

The cars also have electric fans and electric heaters. There are four ceiling fans per car, each having four blades of the propeller type 38 in. long tip to tip, driven by a 150-volt electric motor at 380 r.p.m., the four motors being connected in series; and 24 heater coils per car, each of 550 watts capacity (divided into three degrees of heat), located under the seats.

As already stated, it is possible for a single guard to control the side doors of an entire train if desired. In such case, by means of a commutating switch mounted under the platform roof the car control circuits are connected to the control bus lines, which are completed between cars by jumpers of the usual type. The jumper heads are unusually large and sturdy for the greatest possible reliability. When the doors are closed, however, no control current passes between cars. The guard is provided with two push-button boxes, each having an opening and a closing button, one box for each side of the train. All doors of a car (on one side) open and close together, except the side end doors of end cars at short station platforms, which doors are specially disconnected from the door-control system. Mechanical locks operated by an air cylinder are pushed into place behind each door when it is closed, to prevent them from opening while the train is in motion. Small lamps are mounted over the center side doors, and do not burn unless all doors are closed and the mechanical locks are in place. Each door is provided with a sensitive door edge enclosed in a sheet-rubber protecting cover, which latter consists of two springs which are forced together if the door edge strikes any obstruction in the door opening. The contact of the two springs completes an electrical circuit in which is included the opening magnet valve of the door engine, causing the door to open at once. The door starts to close again immediately. If the obstruction has not been removed, the opening and closing of the door will be repeated indefinitely. As soon as all side doors are closed and locked, a signal lamp in the motorman's cab burns. This does not require any attention by the guards. A bell cord for passing the starting signal to the motorman is also provided. In general, all wiring is single-conductor, each wire in a separate iron conduit, to prevent leakage of



SUBWAY CAR OF THE NEW YORK RAPID TRANSIT CORPORATION

current or crossed wires. A means of opening center doors in case of emergency is provided. By the pulling of a cord inside the car alongside the door the door lock is withdrawn and the door-engine arm thrown off dead center, after which the door may be pushed open.

The motor cars are provided with two motors of the tapped-field type, rated 190 or 200 hp. each, which are of sufficient power to produce an acceleration of a fully loaded train of standard make-up of 1.5 miles per hour per second, and a free running speed of 40 miles per hour (both on a level grade). The multiple-unit control is of the low-voltage type, designed to be operated from a 34-volt battery, and is capable of handling trains of as many as 20 cars.

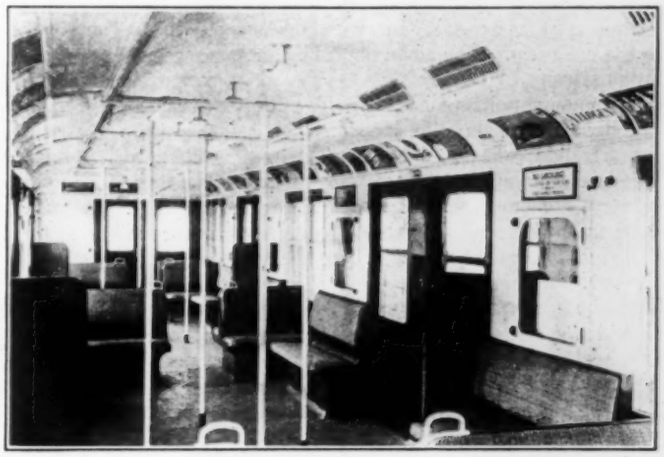
Trucks. The trucks are all-steel, of the swing-bolster type, with a 66-in. wheelbase and 31 1/4-in. wheels, all members being chosen and proportioned to produce a rigid and economical structure. The bolster springs are of the full-elliptic type. Inside-hung brakes are used, proportioned to exert a pressure of 85 per cent of the weight on the wheels. Axles are 6 in. in diameter at the wheel seats, with journals 5 in. by 8 in. Stucki side bearings are provided.

CARS DEVELOPED BY THE NEW YORK RAPID TRANSIT CORPORATION

The New York Municipal Railway Corporation and the New York Consolidated Railroad Company, the predecessors of the New York Rapid Transit Corporation, had no subway cars when contract No. 4 with the city was signed in 1913; hence it was possible to develop a suitable design without the necessity of interchangeability with existing equipment.

The general dimensions of the cars were fixed in accordance with the following limitations:

1 Maximum axle load, 30,000 lb.
2 Distance between centers of railroad tracks, 13 ft.
3 Maximum height of car above rail, approximately 12 ft.
4 Minimum radius of track curves, 125 ft.
5 Maximum grade, approximately 5 per cent
6 Length of station platform: 480 ft. (afterward changed to 530 ft.) at express stations; 300 ft. at local stations
7 Average speed of fully loaded trains between terminal stations: express service, 25 miles per hour; local service, 15 miles per hour.



INTERIOR VIEW OF NEW YORK RAPID TRANSIT CORPORATION'S SUBWAY CAR

After exhaustive studies of all existing types of rapid-transit cars suitable for use in subways, supplemented by original investigation, the engineers of the Railway Corporation decided on an all-steel car 67 ft. long over bumpers (67 ft. 3 1/2 in. coupling length), 10 ft. wide over door-threshold plates, (9 ft. 10 15/16 in. over the eaves), and 12 ft. 1 11/16 in. high above the running rails, equipped with two 160-hp. motors and multiple-unit control, and intended to be operated in trains of a maximum of 8 cars. The weight, including the latest modifications, approximates 94,000 lb. without passengers.

Particular attention is called to the door and seating arrangement; it is equivalent to three compartments in line, around all sides of which seats are placed, with a pair of doors on each side of the car at the axis of each compartment. By this arrangement the average distance traveled in the car by a passenger entering or leaving has been reduced to 83.6 in. (calculated value), which may be compared with 87 in., the lowest for other cars of the kind existing in 1913. The seats are of a special contour developed in collaboration with the American Posture League. The seating capacity is 78 in rush hours, but movable seats are provided which may be lowered if desired, the use of which brings the seating capacity up to 90. These cars have carried as many as 300 passengers, seated and standing. Nine hundred of these cars, substantially duplicates, have been delivered on the line, and 50 more are on order. The earlier cars were fully described in the technical press and a brief bibliography of such articles is appended.

The other special features of these cars may perhaps be most conveniently explained by reference to the group of 50 cars above mentioned, now in course of manufacture. These are being equipped as trailer cars, but may be converted into motor cars by adding merely motors and control.

Body. The body is built on a skeleton of rolled and pressed steel. The floor framing consists of two 7-in. and two 8-in. channels

extending the full length of the car, held in place by steel pressings at frequent intervals, the whole forming a rigid structure capable of resisting heavy buffing shocks or the impact of collisions, etc. Hedley anti-climber buffers are provided at each end of the underframe. The side framing consists of pressed-steel posts thoroughly braced; the sheathing is $^3/_{32}$-in. sheet steel. As already stated, there are three pairs of doors per side, each door opening being 32 in. wide. The roof is of the monitor type, with 20 ventilators per side of the deck sash type. The floor is of Flexolith. The seats provide a width of approximately $17^1/_2$ in. per passenger. The route and destination signs are located in the side walls of the cars near the center doors. Two separately adjustable rolls of cloth are provided, one carrying the names of the different routes on the system, the other the names of the different termini of the runs. Three-inch letters are used, which are unusually legible. There are 28 swinging handholds provided in each car in addition to iron-pipe stanchions. All doors, including one at each end of the car, 14 in all, are operated by electropneumatic door engines of the geared type, which are adjusted to close the doors in about three seconds, the limiting rate being under two seconds. The body bolsters, two in number, are of the built-up type. The draft gear is of the friction type, attached to an eye which is framed into and riveted to the car body. The air-brake connections betwen cars are made automatically by the draft gear. The air brakes are Westinghouse electropneumatic, type AMUE. The interior finish is white enamel and light green paint; the exterior finish is dark green. The painting schedule calls for 6 coats. The roof is lined with Agasote. The brake cylinder and accessories, door-control switches, storage battery, etc., are grouped under the center of the car, as usual (and in motor cars the control equipment and air compressor).

Body Electrical Features. There are two systems of lighting in the car, normal and emergency. The normal lights are supplied from the third rail and consist of 20 shaded 56-watt ceiling lamps in three rows, one along the axis of the car and one over each row of side seats. This arrangement of lights produces a minimum illumination of 3 foot-candles on a plane 3 ft. 6 in. above the car floor with 85 per cent of line voltage. The emergency lighting consists of 6 small lamps, supplied with energy from a 32-volt storage battery of Edison cells such as is used for motor and door control. There are several means provided for charging the battery. The emergency lights are automatically switched into service by a relay upon failure of the normal power supply.

The entire car equipment is arranged so that one guard may control the doors of two or more cars. Some of the cars are permanently connected in groups of three, the remainder being single cars capable of being made up into groups of any size. A four-car train usually consists of a three-car unit and a single car, a seven-car train of two three-car units and a single car. Three-car trains are operated by one guard; four-, five- and six-car trains with two guards; seven- and eight-car trains with three guards. The guard's station in a car is between the two center doors, where a push-button control board is provided for his use. In the three-car unit the guard is stationed at the center of the middle car. In these three cars he can open all side doors, open two adjacent end doors to the right of where he is standing, close all doors to his right (side doors), close all side doors to his left, close doors in front of him, close end doors to his right, close end doors to his left. These doors are on one side of the train only; the doors on the opposite side are controlled by a separate button board. These operations are made possible by electrical control of the magnet valves of the door engines, using energy supplied from the 32-volt battery already mentioned. All the doors of a train are provided with interlocks which are connected into a single circuit that is completed through the motor-control circuit of motor cars; it is arranged so that it is impossible to start a train until all doors are closed or within $1^1/_4$ in. of being closed. Thus an obstruction $1^1/_4$ in. wide in the door opening will prevent a clear signal to the motorman. It is impossible to open the doors while the train is in motion. The motorman has a lamp in front of him, which is lighted when all car doors are closed; there is a buzzer signal also which is passed from guard to guard to the motorman for a "proceed" signal in case of temporary failure of the lamp circuit. Push buttons on the outside of the car and also mechanical tripping levers are provided to permit opening doors from outside the car if desired. Inasmuch as there is only one guard to a three-car unit, who stand in the center car, call boxes are provided in the end cars whereby the guard may be summoned in case of need. In order that the guard may announce station names in all cars, loud-speaking telephones (two per car) are installed in the end cars of each three-car unit.

The cars also have electric fans and electric heaters. There are five ceiling fans per car, each having 4 blades of the propeller type 38 in. long tip to tip, driven by a 120-volt electric motor at 380 r.p.m., the five motors being connected in series; and 30 heaters per car, each of 700 watts capacity (divided into three degrees of heat), located under the seats.

One motor is located on each car truck of motor cars; the motors are of the tapped-field type and of sufficient capacity to produce an acceleration of a loaded train (270 passengers per car) of 1.25 miles per hour per second, and a free running speed of 40 miles per hour, both on level grade. The multiple-unit control is of the low-voltage type, designed to be operated from a 32-volt storage battery. It is capable of handling trains of 16 cars, which is twice the maximum length of a train of the present standard. The control circuits are extended from car to car by power-operated commutating switches, known as "slides," built into the car couplers. There is also an empty and load brake attachment, by means of which the motor accelerating current is increased with the passenger load. A 36-ft. air compressor is standard for these cars.

Trucks. The trucks are all-steel, of the swing-bolster type, with an 80-in. wheelbase and 31-in. wheels, with pressed- and rolled-steel side frames, all members being of ample section and securely riveted together. The bolster springs, two in number, are of the full-elliptic type. The brakes are of the clasp type, using malleable-iron shoes, and are proportioned to exert a pressure of 85 per cent of the weight on the wheels. They are equipped with slack adjusters. Axles are $6^1/_2$ in. in diameter at the wheel seats, with journals 5 in. by 9 in. Stucki side bearings are provided. (The wheels of motor trucks are $34^1/_4$ in. and 31 in. in diameter.)

Other Types of Cars. The experience already gained with cars equipped as described above led the engineers of the corporation to make other experiments, two of which are described here.

The first is to be applied to the existing elevated cars, of which the corporation owns more than 900. The wooden bodies are set upon and firmly attached to steel underframes which are coupled together in threes by long drawbars, forming a draft-gear system entirely independent of the car bodies, and one capable of withstanding service shocks and impacts. The bodies are rebuilt to have two doors per side (and no end doors of the unit), both of which are operated by one geared door engine. This engine is of a late type, with a single magnet valve and a differential air piston for control instead of two magnet valves. The guard's station is at the end of a three-car unit instead of in the center of the middle car, as already described for steel cars. One six-car (two-unit) train of this type is in experimental operation.

The second scheme has been developed from certain ideas already on trial in Europe, and is known as the "articulated" train. Four units of this type are substantially as long as eight of the present standard cars. Each unit has a body of three sections articulated together and supported on four trucks. The special features are stated to be no intermediate end doors, location of guard at end of unit, and possibility of more efficient motor control. In the first design wide single side doors are shown instead of pairs of narrower doors, to save space.

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Use of Pulverized Coal in Open-Hearth Furnaces

Comparison of Pulverized Coal with Other Fuels—Its Disadvantages in Open-Hearth Operation—Data on Steel Production with Pulverized Coal and Producer Gas

By R. H. LOWNDES,[1] ATLANTA, GA.

IT HAS BEEN well said that energy is the foundation of industry; therefore it behooves those interested in industry to study closely at all times all the possible phases of the development of energy. There are at most but few sources of energy, three of which are direct and a small number indirect. Further, the three so-called direct sources may all be attributed to but one source. These three are wind, water, and heat. It is not the purpose of this discussion to elaborate on the sources of energy, but rather to pass directly to one specific phase of the last-mentioned source, namely, heat.

Industrial heat energy is obtained by the burning of fuel, which is the bringing together of any two substances that will unite chemically with evolution of heat. Oxygen, one of the most plentiful of substances, is very active chemically, and carbon, the most abundant of all substances, has a strong affinity for oxygen. It is most reasonable, therefore, that these two elements should constitute our chief sources of heat.

Oxygen is of course obtained from the air, and carbon principally from coal. In the burning of coal with air, then, lies the chief source of our heat-derived energy. Our principal effort is to obtain the maximum heat by the best methods of burning. The purpose for which the heat derived is to be used is the principal factor in determining the choice of the method of burning.

Basis of Comparison of Pulverized Coal with Other Fuels

It is the purpose of this paper to discuss specifically the burning of coal in the pulverized state for the production of steel in the open-hearth furnace, and to determine, if possible, whether or not this application is a good one. This can of course be judged only on a basis of comparison with the use of other fuels and other methods of burning. This comparison involves the study of three factors:

1 The cost of the fuel burned, based preferably on the tons of steel output in order to care for the quantity of steel produced
2 The quality of the steel produced, and
3 The consequent cost of repairs and upkeep of the furnace and its accessories.

In considering the first of these factors it is necessary to take into account:

a The cost of coal per ton
b The cost of milling per ton
c The possible losses consequent upon this milling.

By milling is meant the crushing, drying, and pulverizing of the coal and its delivery to the burners along with the necessary air.

Item *a*, the cost of the coal, is always known. Item *b*, the cost of milling, includes several costs which are readily determined. First is the cost of installation of a coal mill, on which investment a reasonable rate of return must be figured. Thus if the coal mill cost, say $25,000, a return of 6 per cent would mean $1500 per year. This divided by the tons of coal milled should be added to the cost of fuel per ton. Also a reasonable sinking fund, reckoned as a percentage of the investment, should be set aside for depreciation and obsolescence; and this, too, should be added to the cost of the fuel. Insurance should likewise be reckoned as an annual expense and charged to the cost of the fuel. Next, the cost of power to drive the mill with its crushers, driers, pulverizers, elevators and conveyors, air compressors and fans; the labor cost, and cost of repairs and upkeep, oil, waste, etc.

The possible losses in fuel value in milling, item *c*, are more difficult to reckon. They are due principally to:

Coal burned to dry the fuel in the drier
Loss in volatile combustible driven off in the process of drying
Loss in leakage of coal dust
Loss in occasional emptying of bins to prevent packing or spontaneous combustion
Loss in fires which occasionally take place.

In considering the second factor, the quality of the steel produced the following items enter:

d The kind of coal used; its constituents other than carbon; the kind and amount of so-called impurities, moisture, volatiles, sulphur, and ash being the chief items. Each of these may affect the steel
e The control of the flame, not only chemically but also as to intensity, direction, shape, and velocity.

The losses enumerated under item *c* are all small, and for a broad discussion need be noted only, and then perhaps discounted. The coal burned to dry the fuel may be neglected since this additional amount is automatically consumed in any method in first driving off the moisture before the available heat in the fuel becomes obtainable. The loss in volatile is apparently quite small. The best available data on this particular point show an average loss of something less than 1 per cent. It seems to be admitted that here is a small loss, but not enough to cause any concern. H. R. Collins, in a paper written in 1918, stated that driers were manufactured which were able to eliminate moisture without distilling any of the volatile combustible matter in the coal. He then described the modern drier, employing temperatures not greater than 300 deg. fahr., and stated that the volatile combustible matter was not likely to be driven off until the temperature rose above 400 deg. fahr.

The loss in coal-dust leakage is purely a mechanical one, and the latest mills have almost entirely stopped this leakage. Until they did so, however, this loss was quite heavy. The loss in having to empty bins is also minimized by increased knowledge of the quantities of fuel necessary in any specific operation, and the consequent prevention of large accumulations in the bins. This same control also minimizes the loss due to fires, and in the modern mill they are almost unknown.

Assuming, then, that coal can be pulverized at a cost of something like 65 cents per ton (J. W. Fuller estimates that coal can be pulverized and delivered to the burners for 35 cents per ton, as compared to 60 cents per ton for gas producers), with coal costing, say, $6.50 per ton, the milling adds about 10 per cent to the cost of the fuel. We have a right to expect this to be returned by virtue of the much-improved burning; and indeed, so far as the heat obtained is concerned, this additional expense is more than justified. This loss is less expensive than the B.t.u. loss in the gas producer. With good burners and proper air adjustment, what may be termed the carburation of the coal dust is so good that the combustion is excellent. Analyses of the products of combustion show the percentage of CO_2 to be very high, in some cases as high as 15.8 per cent. H. R. Collins, of the Fuller Engineering Co., reports tests where this value reached 17 per cent. The excess air necessary is small, only about 18 per cent, and at the very high temperatures reached the sulphur is also largely burned and carried off up the stack as SO_2.

The flame may be directed, lengthened, shortened, made oxidizing or reducing as desired, and the temperature may be kept remarkably constant at any desired point within quite wide ranges.

Disadvantages of Pulverized Coal in Open-Hearth Operation

All of this leads to the belief that pulverized coal is indeed an ideal fuel; for some uses this may be so, but we have not yet considered the third factor in our discussion of open-hearth operation, namely, the cost of repairs and upkeep of the furnace and its accessories. It has been our experience at The Atlantic Steel Company that herein lie the greatest difficulties. We have found the condition of our coal-fired furnace after 100 heats is worse than the condition of a similar furnace, oil-fired, after 287 heats. The

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gas-fired furnaces suffer even less. In round numbers we have got about three times the heats from our other furnaces that we have from the coal-fired furnace, where the refractories cut away, the slag pockets fill faster, and the checkers become choked.

It appears that the excess air carried along with the sweeping flame at the terrific temperature attained so rapidly will attack and cut the refractories more than it does with either the oil or the gas flame. Compared with the gas flame this is not so surprising, but when compared with the oil flame we must seek more closely for a cause of the difference. There are some who attribute the possible cause of the rapid cutting of the refractories with the coal flame to the presence of incandescent ash particles impinging at high temperature in conjunction with the highly heated excess air. This ash, it is supposed, may start some sort of slagging action, which lays the surface of the brick more open to the attack of the oxygen. Certain it is that the ash has a pronounced effect on the slag of the bath. But the chief source of annoyance and expense lies in the deposit of ash as slag in the slag pockets and in the checkers. This takes place very rapidly, and the toughness of the deposited slag is very pronounced. We found that a high stack velocity lessens this deposit materially; but this increase of stack velocity is obtained at the expense of several things. It calls for additional excess air to increase the volume of gases passing so as to increase the velocity. This of course at once reduces the temperature of the flame, but at the same time it increases the cutting effect on the refractories. To carry off this extra volume of flue gas necessitated our passing the gases from the checkers directly to the stack, cutting out the waste-heat boiler. This is of course another serious loss of heat energy. Attempts to use the waste-heat boiler reduced the flue-gas velocity so that the slag deposited very rapidly, and the checkers became badly choked. This choking of the checkers further reduced the gas velocity, which caused a further drop in flame temperature, which in turn seemed to cause more sulphur to enter into combination in the steel. Both the temperature and intensity, as well as the direction of the flame, had to be kept within certain limits to avoid sulphur troubles. It seems that the sulphur oxidizes and passes off as SO_2 at and above certain temperatures. This is doubly advantageous, as the sulphur is not only gotten rid of but it generates heat in burning. When the temperature falls below this critical value the sulphur prefers the iron to the oxygen and goes into the steel, combining in more than one compound. So to get rid of the sulphur the flame intensity should be high, the flame should not be depressed—that is, it should be directed above the bath, and the excess air must be adjusted within narrow limits. Too little excess air and the sulphur is not oxidized; too much, and the temperature drops, and again the sulphur is not oxidized. When these several adjustments are about right to effect a maximum riddance of sulphur, the velocity of the gases is reduced to a point where the refractories cut and the slag deposits heavily.

Cutting off the waste-heat boiler and increasing the excess air increases the flue-gas velocity and lessens the ash and slag deposit; but the refractories cut faster, the temperature of the flame drops, more sulphur enters the bath, and the use of the boiler is entirely lost.

The experience here recounted ran over a period of about seven years, 1916 to 1922, inclusive. These years were seriously affected by war conditions, both high and low peaks being reached in that time. It has been difficult, therefore, to compile any very fair set of data. But the conspicuous and interesting fact is that both study and experience have clearly shown us that the major objections to the use of pulverized coal in the open-hearth furnace lie not in the preparation nor in the burning of the coal, but almost entirely in that part of the work which coal-burning literature touches on so little or not at all, namely, the consequent clean-up, upkeep, and repairs.

There is but one way to correctly evaluate pulverized coal as a fuel for the open-hearth furnace, and that is to watch the industry for a decade or two longer. With the ever-increasing improvements for taking care of difficulties as they present themselves, this type of fuel may indeed come to be more and more used in open-hearth work. But at the present time, it is necessary to state that, the Atlantic Steel Company has just discarded its coal-fired furnace because of the higher cost of producing steel by this means.

Comparative Costs of Open-Hearth Operation with Pulverized Coal and Producer Gas

In Table 1 will be found a few brief figures taken from data accumulated during 1922. This year was chosen as being most nearly representative, since prices of commodities and labor, and of production in general, were then somewhere about midway between the high peak of the war and the low peak of the subsequent depression. These figures show some of the actual costs, and these in turn show why this method of open-hearth operation was abandoned by The Atlantic Steel Company.

TABLE 1 DATA ON STEEL PRODUCTION IN OPEN-HEARTH FURNACES BURNING PULVERIZED COAL—ATLANTIC STEEL CO., 1922

Date	Fuel			Steel			Repairs	
Month	Dollars per ton coal	Dollars per ton coal for milling	Pounds coal per ton steel	Tons steel output	Heats per furnace	Sulphur in steel per cent	Dollars per month	Dollars per ton steel
Apr.	4.83	0.67	668	2271	49		343	0.15
May	4.95	0.60	740	2580	52		771	0.30
June	5.23	0.68	1170	412	9			7.28
July	5.40	0.61	580	2453	50			1.98
Aug.	6.84	0.60	660	2124	44		1247	0.59
Sept.	7.22	0.82	630	2048	42		1713	0.83
Oct.	7.38	0.56	638	1768	37		3526	2.00
Nov.	7.49	0.52	666	2383	47		3468	1.46
Dec.	8.27	0.58	664	2370	47		1261	0.53
Avg.	$6.40	$0.62	636[1]	2068	42	0.065	$1761	$1.68
Do., for gas[2]	$6.40	$0.60	548	2016	39	0.045	$1361	$0.96

Tennessee coal used, averaging 36 per cent volatile, 53 per cent fixed carbon, 3½ per cent moisture, 6 per cent ash, and 1½ per cent sulphur.

Dried at an average temperature of 200 deg. fahr., to about 1 per cent moisture.

Average pulverization showing 98 per cent passing 100-mesh screen and 81½ per cent passing 200-mesh screen.

[1] This figure obtained by dividing total coal consumption by total steel output.

[2] Average for the same months for two gas fired furnaces.

It is apparent at a glance from the figures in Table 1 that the gas-made steel is both better and cheaper. It is also apparent that the chief objections to the use of pulverized coal lie in the difficulties engendered in the necessity of running the ash through as a part of the products of combustion.

In a report on Pulverized-Coal Systems in America, compiled by Leonard C. Harvey, and published in London in 1919, under the heading "Opinions of Users" occurs the following statement:

> Have found the average life of checkers for various fuels in the open-hearth furnace to be—
>
> | | |
> |---|---|
> | For natural gas | 1000 heats |
> | For producer gas | 350 to 500 heats |
> | For oil | 350 to 500 heats |
> | For pulverized coal | 225 to 250 heats. |

This report shows that the Atlantic Steel Company is not alone in its findings as to the life of checkers.

Use of Pulverized Coal in Soaking Pits

The Atlantic Steel Company is continuing its use of pulverized coal in the soaking pits, where the results are far more satisfactory than they were in the furnace, but are not so good as with the producer gas. The slag and ash deposit of course takes place in the combustion chamber, in the soaking pit proper, and at the base of the stack. But this deposit is more readily removed and need never be allowed to accumulate sufficiently to choke the passages. The flame may be made either oxidizing or reducing, and since the steel remains in the solid state the sulphur gives no trouble. For soaking-pit operation the use of pulverized coal appears to be acceptable. We have not used pulverized coal under boilers, except indirectly under the waste-heat boilers from the open-hearth furnace.

It is very interesting to note that in spite of the promising outlook presented by the possibilities in the use of pulverized coal, in actual practice the use of this fuel in open-hearth operation proved with us, as with others, to be unsatisfactory. Nor must it be forgotten that the trouble lay in that part of the operation which is not found in a study of the combustion.

There is reason to hope and to believe that the near future will enable the open-hearth furnaces in small as well as large plants to use pulverized coal as a fuel; but before this can be done there must be some experimenting, and the smaller plants must await the results of these experiments, which only the larger plants can be expected to perform.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Large Boiler Plants in the United States and Germany

By DR. ING. FRIEDRICH MÜNZINGER

THE author of this book is a director of the Allgemeine Elektricitäts Gesellschaft (A. E. G.) of Berlin, one of the largest electric companies in the world. His knowledge of American conditions is somewhat second-hand, but nevertheless apparently good. It is based on the careful reading of such literature as the Reports of the Prime Movers' Committee of the National Electric Light Association, *Power*, and similar trade publications, and an extensive correspondence with American engineers. His knowledge of German conditions is naturally thorough, as his opportunities for studying them are exceptionally good.

The opinions of such a man as to the comparative methods used in the two countries cannot help being of interest, and the only regret is that enough space is not available to report them more fully.

One feature in American plants that impressed the author is the use of immense boiler units, culminating in the enormous Connelly boilers of the Congress Street Company plant of the Detroit Edison Co.

However, the steam temperatures employed are lower in America than they are in Germany where temperatures at the superheater exit of 350 to 375 deg. cent. (662 to 707 deg. fahr.) are becoming quite common. Economizers are not used to the same extent as in Germany. Considering everything, however, the author comes to the conclusion that American engineers have made extraordinary progress in both the theory and practice of boiler design.

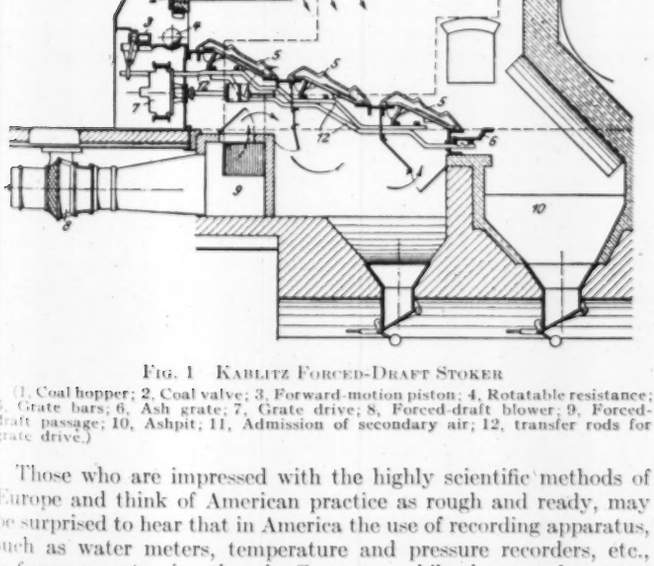


FIG. 1 KABLITZ FORCED-DRAFT STOKER

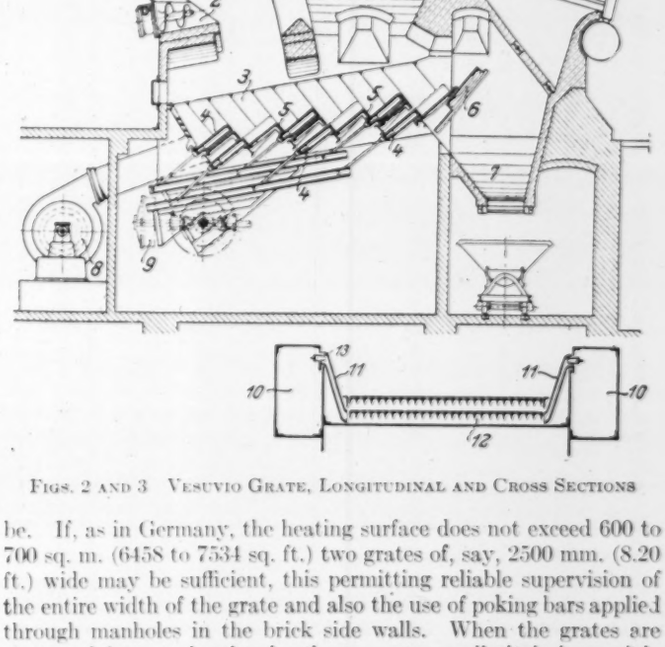
(1, Coal hopper; 2, Coal valve; 3, Forward-motion piston; 4, Rotatable resistance; 5, Grate bars; 6, Ash grate; 7, Grate drive; 8, Forced-draft blower; 9, Forced-draft passage; 10, Ashpit; 11, Admission of secondary air; 12, transfer rods for grate drive.)

Those who are impressed with the highly scientific methods of Europe and think of American practice as rough and ready, may be surprised to hear that in America the use of recording apparatus, such as water meters, temperature and pressure recorders, etc., is far more extensive than in Germany, while the use of systems where all the recording apparatus are concentrated in the operator's cabin, is preëminently American.

As regards stokers, in the larger German power plants the traveling grate is the most usual type for burning ordinary coal. Overfeed stokers are used only sparingly and then preferably for the lower grades of fuel, while underfeed stokers have found practically no market at all. Overfeed grates and stepped grates are used in Germany almost exclusively for low-grade brown coals (a fuel somewhat similar to the American lignites). There are no similar types at all in America, though it is true that increasing attention is being paid to lignite burning in the United States, but only for comparatively high grades of that fuel.

In America grates are very much wider than in Germany, the author mentioning some 7300 mm. (24 ft.) in width; in Germany, however, units wider than 2500 mm. (8.20 ft.) are exceptional, and those of 3000 mm. (9.8 ft.) width are very rare, indeed.

The author believes that the question is not so much how wide the grate surface is as what the heating surface of the boiler should



FIGS. 2 AND 3 VESUVIO GRATE, LONGITUDINAL AND CROSS SECTIONS

be. If, as in Germany, the heating surface does not exceed 600 to 700 sq. m. (6458 to 7534 sq. ft.) two grates of, say, 2500 mm. (8.20 ft.) wide may be sufficient, this permitting reliable supervision of the entire width of the grate and also the use of poking bars applied through manholes in the brick side walls. When the grates are separated from each other by three or more walls it is impossiole to follow clearly what happens in the middle grate, and this will usually affect the efficiency of operation.

In Germany overfeed stokers for ordinary coal firing are just beginning to make their way. The Pluto forced-draft stoker is the only one that has found wide application in continental Europe, especially in Austria and Czechoslovakia. Considerable attention has been attracted to the Kablitz forced-draft stoker shown in Fig. 1. The characteristic feature of this type is the presence of the rotatable resistance at the front end and the saw-tooth shape of the grate itself. As a result of the combination of these elements the lower layer of the fuel bed moves over the grate slower than the upper level, this producing at all times a more certain ignition of freshly fed fuel. Every second grate bar is movable. Furthermore, in order to produce a more vigorous stirring action and also to reduce the possibility of bars covered by the fuel burning out, the forward and upward motions take place alternately. As a result of this, most of the time the bars form a smooth surface, thus reducing the chance of the exposed edges of the bars burning away.

Of the two novel methods of burning German brown coal, which, as has been stated, is somewhat similar but not identical with American lignites, may be mentioned the Vesuvio cascade grate (Figs. 2 and 3). On this grate the fuel rests in a trough the bottom of which is formed by the grate bars proper, while the fairly elevated cheeks consist of hollow castings cooled by the forced draft flowing through them. This tends to keep the freely melting slag from clinkering on to these elements. Some of the steplike grate stages are stationary while the stages located ahead and beyond them move contrariwise to each other, i.e., when some go up the others go down. This arrangement of the Vesuvio grate leads to some interesting results which are discussed in detail by the author.

The author discusses next why it is that traveling grates are practically exclusively used in Germany, while in America three fundamentally different types of stokers are employed. This is due not only to technical but also to historical and geographical considerations. Each kind of coal burns especially well on a grate suited to its chemical and physical properties. For example, the nonclinkering coals burn best when the fuel bed is not disturbed, while with clinkering coals some way of shifting the fuel around is of advantage. However, the difference between the various kinds of coal is not distinctly apparent, and in addition to this some one feature of a given coal may be partly overshadowed by the influence of another feature. It is therefore quite possible for stoker manufacturing companies to create a wider market for their types than they are entitled to, and in the opinion of the author this is apparently the case in America.

According to the author, underfeed stokers are preferred in America for coals containing less than 10 to 12 per cent of ash, while traveling grates are used for coals with a higher ash content, the American opinion being that when a low-ash coal is used on traveling grates the rear end of the grate is apt to be covered with a bed that is too thin, thus causing air leakage. Furthermore, it is said that under these conditions, especially with certain coals, the grate, on account of the thin layer of fuel and ash, is apt to be burned out easily when the power demand suddenly falls off or when the furnace is operated with a low fire for a long time. It is a matter of surprise to Dr. Münzinger that a 10 per cent ash content is considered to be the lowest permissible with a traveling grate, as in Germany perfectly satisfactory results are obtained with an ash content of not more than 8 per cent. He does not venture an opinion as to the extent to which this difference is due to the difference in composition of American and German coals outside of ash percentage, or to the difference in the closing devices used at the rear end of the grate. The feature in underfeed stokers that appeals particularly to Americans is their ability to adapt themselves quickly to high peak loads, a matter which, as the author shows elsewhere, is of somewhat less importance in Germany.

PULVERIZED-FUEL FIRING

The author devotes a great deal of attention to American developments in this field. It would appear that in Germany an earnest effort has been made in the same direction during the last three years. Attempts hitherto unsatisfactory have also been made in certain other directions which the author considers as being somewhat hopeless. Thus, an unsuccessful effort was made to burn coarsely pulverized fuel with a grain size from $\frac{1}{2}$ to 1 mm. (0.02 to 0.04 in.). The A.E.G. has investigated the burning of finely pulverized coal and has developed a burner. Initially the intention was merely to provide a system of combustion for their own use which would enable them to burn whatever kinds of coal that happen to be available in these days of fuel shortages. These pulverized-coal burners have in the last two years taken care of the greater part of the steam requirements for the two factories of the company and have handled in that time all kinds of coal that were delivered, from Silesian coal rich in ash, to middle German brown coals, coke, semi-coke, anthracite, Brazilian coal rich in sulphur, etc.

The experiences in Germany seem to have led to a belief in the great importance of very fine pulverization and a thorough mixing of the coal with the air. The construction of the pulverized-coal burner of the German company is shown in Fig. 4. In order to effect the uniform mixing of the air and the pulverized coal, this burner contains at the fire end of the worm shaft a conical casting, 5, which scatters the coal dust over its entire surface through the concentrically incoming air and thus produces such a perfect mixture of dust and air that there is no trace of black dust in the flame even directly over the burner exit.

From this point of view Fig. 5 is of interest, in that it shows the distribution of temperatures along the path of the flame in the boiler shown in Fig. 6. It would appear from this that notwithstanding the best possible mixing of coal dust and air, the maximum temperature is reached only at the distance of two meters (6.56 feet) from the burner. Actually, however, even here the combustion is not entirely completed, since directly back of the point of measurement II the flame is being cooled off through radiation to the cold surface which tends to counteract the evolution of heat produced by still further combustion. It would appear that in order to obtain perfect combustion a certain minimum distance has to be provided between the tip of the burner and the water tubes of the boiler, this distance depending on the kind of coal burned. If this distance is too short considerable losses occur through incomplete combustion. The connection between these factors is comparatively little known or considered because a high CO_2 content and an apparently perfect flame may be obtained even where the distance specified above for the development of the flame is insufficient. Where this occurs, however, great losses due to incomplete combustion are inevitable and the content of unconsumed fuel in the ash may run as high as 20 to 40 per cent.

There are other considerations that govern the minimum size of the fire chamber or flame path, meaning by the latter the distance between the tip of the burner and the water tubes. Because of their fine state of pulverization the ashes are carried with the flame and with most coals are apt to fuse together. If these molten ash particles can travel for a sufficient length of time through a zone of temperature lying below their melting point before they

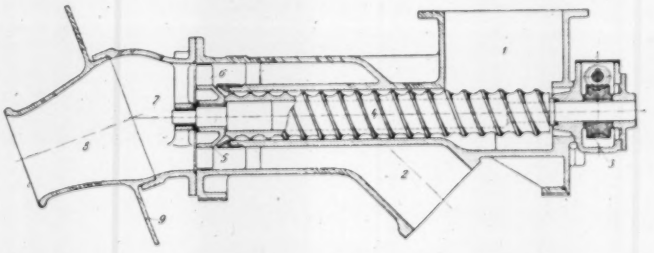


FIG. 4 PULVERIZED-COAL BURNER OF THE ALLGEMEINE ELEKTRICITAETS GESELLSCHAFT

(1, Coal-inlet hopper; 2, Combustion-air inlet; 3, Drive; 4, Worm; 5, Mixing cone; 6, Vane; 7 and 8, Burner orifice.)

reach the cool tubes, they solidify and the iron suboxide contained in the ash is converted by absorption of oxygen into the iron oxide having a much higher melting point. As the author shows, the minimum length of the flame path is therefore determined by two considerations: the necessity for complete combustion of the pulverized fuel, and for solidification and oxidation of the liquefied particles of ash. Unless this is done, slag deposits will form on the water tubes and this will rapidly result in serious disturbances of operation.

Coals rich in gases require, as a rule, a shorter distance or time of flame travel for complete combustion as compared with coals of the anthracite type or those poor in gas. The more graphitic a coal is, the more it requires a long flame path, fine pulverization, and high temperature in the fire room.

As regards the dimensional proportions of the furnace, the conclusions at which the engineers of the A.E.G. have arrived from their experience do not appear to differ in any material way from what is already known in this country.

As regards the general design of modern water-tube boilers, the author believes that the proportioning and arrangement of the water and steam spaces and their connections are capable of improvement. In particular, according to his view not enough attention is paid to the fact that the dimensions of these parts depend not only on the size of the boiler but also on the specific load on its heating area. As regards certain American water-tube boilers, he is of the opinion that their designers still have ahead of them the solution of problems which have already been solved in Germany

and he is not surprised at the frequent complaints about insufficient or irregular superheating, priming, etc.

German practice has shown it to be entirely possible to build water-tube boilers in such a manner that even at very high loads they will deliver dry steam, and that the superheat will be maintained practically uniform within a wide variation of load. When superheating is irregular the fault practically always lies in improper proportioning of the cross-sections through which the water and steam circulate or of the steam and water spaces, although occasionally this may be due to an excessive content of salts in the water. Since the beginning of the war no new boiler types have been placed on the German market, but a great deal of attention has been paid to the improvement of boilers of the old types. In this direction material assistance has been lent by the research work conducted by the Association of Large Boiler Owners, and dealing especially with selection and testing of materials of construction and riveting and building of the drums. As a result of these efforts all riveted seams not absolutely necessary have been eliminated and seamless drums are now used in preference to riveted ones.

Superheaters and Economizers

The first point that the author stresses in this connection is that in America, and differing from German practice, superheaters and stokers as a rule are not built by the boiler manufacturers. As a result there are a large number of superheaters on the market, and those fitted to particular boilers do not always work well with them. He points out that superheat temperature regulators built

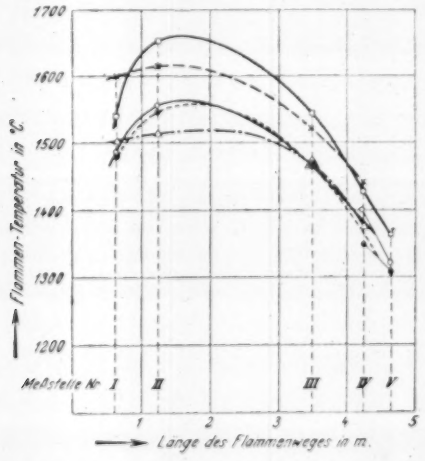


FIG. 5 TEMPERATURE DISTRIBUTION IN THE FLAME OF THE BURNER SHOWN IN FIG. 4 WITH VARIOUS KINDS OF COAL AND UNDER VARIOUS CONDITIONS OF COMBUSTION

(Ordinates: Flame temperatures in deg. cent. Abscissas: length of flame in meter. *Messstelle* = point of measurement.)

into the upper drum of the boiler are practically unknown in America. With all their advantages they have the disadvantage that they make access to the water tubes more difficult, and that in large power plants a change of temperature requires an adjustment of a large number of regulators. A German company has brought out a central temperature regulator which is built into the main steam-supply line and regulates the temperature of steam as delivered by an entire battery of boilers. It works on the same principle as the regulator built into a steam drum, i.e., a variable part of the superheated steam is led through a pipe surrounded by water and cooled therein. The steam developed from the cooling water is then supplied to the boiler or steam pipe. Regulation of steam temperature is particularly important in the case of large turbines where excessive temperature (above the safe limit) may cause considerable trouble, and where such an excess occurs quite frequently unless proper provision for temperature regulation is made.

Economizers are not used in America to the same extent as in Germany, and even in the latter country the relative costs of production of economizers and boilers are beginning to approach American conditions. The author points out an increase in use of economizers in this country, in particular those made of wrought iron, a practice which has been of decreasing frequency in Germany since 1916.

With cast-iron economizers the pressures in America vary between 11 and 24 atmos., the usual pressures not exceeding 18 atmos. (255 lb. per sq. in.). A German company has developed a novel type of economizer which it is claimed may be safely operated at pressures up to 80 atmos. (1136 lb. per sq. in.), this being due to the use of a construction which prevents the stripping of the economizer tubes.

Air Preheating

The author devotes a considerable amount of space to the subject of preheating the air, which he says is arousing a great deal of

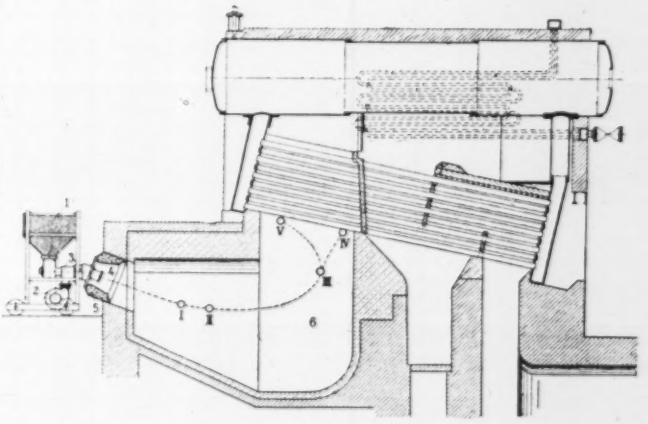


FIG. 6 BOILER USED IN EXPERIMENTS FROM WHICH CURVES OF FIG. 5 ARE DERIVED

(Old type, 200 sq. m. heating surface.)

interest both in Germany and in America. In Germany air preheaters have been used on shipboard and have given good results, but as far as the author is aware, they have not been installed in any of the more important German plants.

There is a certain element of competition between the air preheater and economizer, and the question which one of the two is preferable should not be considered from a thermodynamic point of view exclusively. It is perfectly possible, of course, to install an air preheater behind an economizer and in some cases improve the efficiency by a few per cent. The advisability of this procedure, however, depends on whether the combined depreciation, interest, and maintenance costs of the air preheater are enough less than the savings in fuel cost. Furthermore, the complication of the plant and increased possibilities of trouble must be considered.

Nevertheless it would be wrong to assume that air preheaters have no economic justification in connection with large stationary boilers. In plants where feedwater has a temperature 60 to 70 deg. cent. (140 to 158 deg. fahr.) or higher, where the load on the boilers varies greatly, where it is desirable to increase the steam output of available boilers, and particularly where the fuel is of such a character that it will burn better with warm air, air preheaters are justified and will rapidly pay for themselves. There is also a good chance for air preheaters in connection with pulverized-coal firing or where hot air is used for drying. Thus, for example, air preheaters prove to be valuable in Indian sugar factories where bagasse is used as fuel.

One of the main reasons why air preheaters have been so little adopted heretofore is, in the opinion of the author, that no data are available as to the extent to which grate operation and the efficiency of firing are improved by the use of preheated air and also to what extent the furnace temperature increases with air preheating. He attempts to answer this last question by analytical calculation.

An interesting chapter in the original book—not suitable for abstracting owing to lack of space—is devoted to the subject of heat accumulators, such as the Ruths steam accumulator, in connection with which a special type of turbine, the so-called oscillating turbine, has been developed, its particular feature being that the high- and low-pressure sides never work at the same time. (*Amerikanische und deutsche Grossdampfkessel*, by Dr. Ing. Friedrich Münzinger, 178 pp., 181 figs., *cdA*. Published in Berlin, 1923, by Verlag von Julius Springer.)

Short Abstracts of the Month

AIR ENGINEERING (See Special Processes)

ENGINEERING MATERIALS (See also Machine Parts)

Monel Metal at High Temperatures

Monel Metal for High-Temperature Work. This article reproduces curves (Fig. 1) obtained from G. & J. Weir, Cathcart, Glasgow, Scotland, showing the ultimate tensile strength of monel metal at varying temperatures, in addition to which curves from an article published in a previous issue of the same journal (April, 1923,

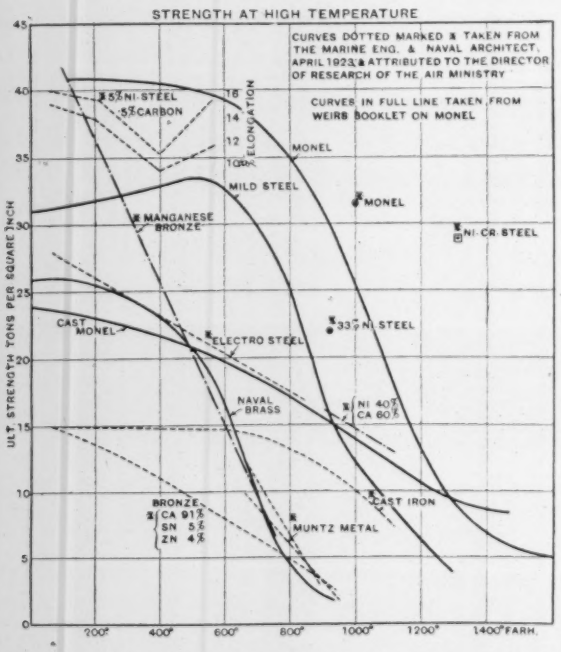

STRENGTH AT HIGH TEMPERATURE
CURVES DOTTED MARKED * TAKEN FROM THE MARINE ENG. & NAVAL ARCHITECT, APRIL 1923 & ATTRIBUTED TO THE DIRECTOR OF RESEARCH OF THE AIR MINISTRY
CURVES IN FULL LINE TAKEN FROM WEIRS BOOKLET ON MONEL
ELONGATION
MONEL
MILD STEEL
MONEL
MANGANESE BRONZE
NI-CR STEEL
CAST MONEL
ELECTRO STEEL
33% NI STEEL
NAVAL BRASS
NI 40% CA 60%
CAST IRON
BRONZE CA 91% SN 5% ZN 4%
MUNTZ METAL
ULT. STRENGTH TONS PER SQUARE INCH
200° 400° 600° 800° 1000° 1200° 1400° FARH.

Fig. 1 Tensile Strength of Various Metals at High Temperatures

p. 125) are reproduced for purposes of comparison. From these curves it would appear that at 700 deg. cent. (371.1 deg. fahr.) monel is stronger than wire steel, manganese bronze, or naval brass. (*Marine Engineer and Naval Architect*, vol. 46, no. 551, Aug., 1923, p. 303, 2 figs., *d*)

Stainless Steels from the Point of View of the Glass Industry, W. H. Hatfield. Stainless steel maintains its strength at high temperatures to a much greater degree than ordinary structural steel. Thus at 800 deg. cent. structural carbon steel has a tensile strength of four tons and stainless steel one of over six and a half tons. In comparison with ordinary carbon steel and even alloy steels and tungsten steels, stainless steel shows a greater resistance to scaling with increasing temperature. A clean metallic surface is, however, necessary for the best rust-resisting results, though it is not necessary to have a highly polished surface provided all scale and pit marks are eliminated. (*Journal of the Society of Glass Technology*, vol. 7, no. 26, June, 1923, pp. 142–148 and 3 photomicrographs, discussion pp. 149–153, *dp*)

Manufacture of Pearlitic Gray Cast Iron in the Electric Furnace. Of late considerable attention has been attracted to the so-called pearlitic cast iron developed in Germany. In pearlitic cast iron the usual structure of ferrite and carbon in flake form is replaced by a structure where the carbon is in a somewhat more finely divided form, and instead of ferrite a mixture of ferrite and pearlite is encountered. This result is obtained first by giving the iron a strictly controlled chemical content. Thus, it is stated that the total carbon must be between 3 and 3.1 per cent, silicon in the region of 1.5 per cent, and the manganese content 0.7 to 0.8 per cent. The next condition is the casting in a fairly hot mold at a temperature of the order of 400 deg. fahr.

The present article gives general data on this material which has physical properties far superior to ordinary cast iron, and, in particular, describes the manufacturing methods used at the works of Brown, Boveri & Co., in Baden, Switzerland. (Translation of article by Dr. H. Frei in *Die Giesserei*, July 12, 1923. *Foundry Trade Journal*, vol. 28, no. 363, Aug. 2, 1923, pp. 95–96, 4 figs., *d*)

Effect of Low-Temperature Annealing on Some Mechanical Properties of Cold-Drawn Steels, S. H. Rees. As a result of cold drawing without subsequent annealing a considerable increase takes place in the value of the yield tensile strength ratio and also in the value of the yield point both in tension and compression.

The directional effect of the cold drawing is marked in the case of the high-carbon steel tested.

The effect of low-temperature annealing on the maximum load and yield point in the case of the mild steel and stainless iron is not appreciable, but they do not decrease in value until the material is annealed above 300 deg. cent.

The elastic limit in all cases is greatly improved by low-temperature annealing.

The directional effect of the cold work is probably a function of the original hardness of the steel and the amount of cold working. It is very noticeable in the values obtained with high-carbon steel, but with other steels it is not so apparent, although in no instance does the elastic limit in compression quite reach the figure attained in tension.

The elastic range is not a constant value in the materials investigated, and from the results given it would seem that the mechanical properties of all cold-worked steels are improved by a low-temperature treatment. (Paper before the September, 1923 meeting of the *Iron and Steel Institute*, abstracted from advance proof, 11 pp., 8 figs., *p*)

FOUNDRY (See Special Processes)

FUELS AND FIRING (See also Gas Producers)

The Utilization of Coke Breeze. Description of practice at the plant of the Bradford Road Gas Works, Manchester, England, which is equipped for the complete mechanical handling and burning of coke breeze under steam boilers, and for the mechanical handling of the resulting ash and clinker. The breeze arrives by overhead telpher conveyor, and from that time to when the cooled and quenched ash and clinker are dumped into carts for conveyance to the tips, the material is never touched by hand.

A good sample of coke breeze will contain about 10 per cent water, 20 to 25 per cent ash, about 65 per cent fixed carbon, and about $2^3/_4$ per cent volatile matter. This will have a heating value of between 9000 to 10,000 B.t.u. per lb. Much breeze, however, contains 20 to 25 per cent water, which materially reduces the heating value and efficiency of the fuel.

Coke breeze is a difficult fuel to burn because of its low quality and fine state of division, the latter being apt to cause great loss by unburned fuel falling through the grate. Another trouble is the large amount of flue dust formed, partly because of the mechanical condition of the fuel, and partly due to the steam-jet forced draft, which tends to blow the material off the fire bars. The consequence is that the flues soon become choked with dust, and have to be cleaned out every six to eight weeks instead of every six to twelve months as with ordinary coal. For these reasons mechanical stoking and water-tube boilers give far more efficient results with breeze.

An Underfeed impelled-draft traveling-grate stoker is used in this instance. The stoker consists of an endless moving chain, heavy box-shaped fire bars mounted on driving chains connected in the usual way to sprocket wheels attached to the driving shaft, and special driving mechanism at the front of the stoker. These transverse box-shaped fire bars are composed of heavy framework, containing inside a number of small fire bars, so that the whole of the slow-moving grate surface consists of a very large number of

these small fire bars with a very widely distributed air supply, and it is practically impossible for any coke breeze to fall through the grate.

The driving mechanism gives eight variations in the speed of travel of the grate. The power is taken from a short motor-driven overhead driving shaft running at about 70 r.p.m., and is extraordinarily small, not more than 1/3 hp. The coke-breeze feed mechanism from the hoppers in front of the stokers is regulated, as usual, by means of a vertical sliding gate raised or lowered by a rack-and pinion; and, by varying the speed of the stoker and the air supply, the amount of coke breeze burned per square foot of grate area per hour is as high as 50 lb.

The forced-draft air supply is obtained from two small electrically driven forced-draft fans built into special casing at each end of the fuel hoppers, thus causing the cold air from the fire hole to be taken in through the fans and delivered through trunking to a wind box at each end of the stoker, means being provided for varying the air so that different amounts of air are allowed to pass into the fuel bed at different lengths of the grate according to the thickness of the fuel bed.

The automatic ash-removal plant is of the Usco patent sluicing system. In this the hot ash and clinker as it comes continuously over the end of the stoker falls into a trough, through which is flowing constantly a stream of water about 3 in. deep, the width of the trough being 21 in. The mass of ash and clinker is quenched at once and swept along in the stream of water in the trough, and is discharged into a large concrete sump in the ground alongside the boiler plant. This sump is 12 ft. by 12 ft. by 15 ft. deep. (*The Gas World*, vol. 79, no. 2037, Aug. 4, 1923, pp. 90–91, *d*)

FROTH FLOTATION AS APPLIED TO COAL, C. H. S. Tupholme. Description of two recent developments intended to render the concentrates from the froth-flotation system of coal washing more suitable for industrial purposes. These developments deal with ways to separate the coal particles from the associated water.

In the first method the froth-flotation concentrates or other powdered-coal particles associated with water are suspended in sufficient water to make a mobile pulp. This pulp is then subjected to agitation, usually with aeration. To this is added an oil, tar, and some other hydrocarbon or carbonaceous liquid which has the property of coating the coal particles and also of causing the coal particles coated to flocculate together, after which the coated and flocculated particles are separated from the water by draining or filtration without being compressed into blocks or briquets.

The removal of water from the coated and flocculated particles may be assisted by pressure. However, it must be remembered that the coating and flocculating agent does not act as a binder and therefore will not suffice as a binding medium in the manufacture of briquets.

This method offers particular advantages when the coal particles are subsequently to be made into coke, because the hydrocarbons in the flocculating agent are distilled in the coking operation and may therefore be recovered. Moreover, the presence of these hydrocarbons in the mass of the flocculated coal particles constitutes an addition of volatile matter which assists the coking of special types of coal, which would otherwise be unsuitable for the manufacture of coke.

The article gives data of tests which would indicate the effectiveness of the process. However, it does not appear quite clearly as to whether it has yet reached the stage where it can be applied on a commercial scale. (*Coal Age*, vol. 24, no. 8, Aug. 23, 1923, pp. 277–278, *d*A)

THE TEMPERING OF COAL, Thos. A. Marsh, Mem. A.S.M.E. The author comes to the following conclusions:

1 Moisture can be added to some coals to definite advantage. This applies to western bituminous coals. (Pittsburgh and west.)

2 Coke breeze, anthracite, and dock screenings burn better when slightly dampened to prevent siftings and blowing of the fuel bed.

3 The effects of moistening are more pronounced on traveling-grate stokers so far as combustion results are concerned.

4 The amount of moisture to be added will average about 3 per cent, which is equivalent to 0.3 per cent decrease in net evaporative effect from the coal.

5 The advantages obtained from tempering coal more than offset the slight decrease in net value of the coal.

6 Steam and hot water temper coal quickly and well but should be used only when a study of gain and loss has been made.

7 Tempering requires time. Cold water added in stoker hoppers does not temper coal.

8 Moisture should be added with discretion and under guidance of some tests to indicate amounts and effect of various items of the heat balance. (*Association of Iron and Steel Electrical Engineers*, vol. 5, no. 9, Sept., 1923, pp. 369–379, 4 figs., *p*)

GAS PRODUCERS (See also Special Processes)

History and Present Practice of the Ash-Fusion Type of Gas Producer

THE ASH-FUSION TYPE OF GAS PRODUCER, E. Servais. The main disadvantages of the conventional type of gas producer lie in the comparatively small output per unit and the high content of carbon dioxide in the gas generated. Furthermore, the cost of operation is comparatively high and the producer requires careful and skilled attention.

The development of the ash-fusion type of producer dates back to the work of a Frenchman, Ebelmen, who built a small unit in 1841. This producer ran on charcoal and gave comparatively good results. The experiments were, however, brought to a premature conclusion by the death of the inventor.

In 1906 Fichet and Huertay, the first named being a relative of Ebelmen, took up the same problem using coal instead of charcoal as fuel. Very serious difficulties arose, however, and they never succeeded in making the unit run regularly. In the same year Victor Sépulchre, a Belgian engineer, built an ash-fusion-type producer quite similar to that of Ebelmen and ran it on local lignites. With this fuel, which gave very poor results in a Siemens-type producer, Sépulchre secured excellent operation. In fact, a battery of six producers of his type ran for many years until the local beds of lignite were exhausted.

Fichet and Huertay entered into a coöperative arrangement with Sépulchre and in 1910 enlisted the interest of a large steel company, the Société d'Ougrée-Marihaye, which placed a cupola in one of its plants at their disposal. The cupola was transformed into a gas producer, the present author taking part in this work, and the results of the initial tests were so encouraging that in 1913 two large units were installed in Germany, two other units being installed later and bringing the production up to a gasification of 200 tons in 24 hr.

The main dimensions of these producers were as follows:

Hearth:	Inside diameter	1.600 m. (63 in.)
	Height	1.800 m. (70.86 in.)
Boshes:	Height	1.200 m. (47.25 in.)
Trough:	Inside diameter	2.800 m. (110.25 in.)
	Height	2.300 m. (90.50 in.)
Total height of apparatus		5.300 m. (208.75 in.)

The brickwork, 35 cm. (14 in.) thick, consisted of blast-furnace-type brick in a sheet-iron frame. Two tap holes were located at the hearth level, 1.5 m. (59 in.) above which were set eight tuyeres made of bronze, water-cooled and connected to a circular air conduit.

The charging device with double closure was placed on the roof of the gas producer and had a capacity of 1 cu.m. (35.31 cu. ft.). There were two diametrically opposite gas outlets leading through parallel conduits to a large gas-holder chamber on top of which was placed an air preheater consisting of a bundle of tubes through which the gas passed, the air flowing on the outside of these tubes. The blast was supplied by two Roots blowers of 2000 hp. capacity each with an output of 200 cu.m. (7062 cu. ft.) per min. at a pressure of 1.200 m. (47.25 in.) of water, the air output being governed by valves.

The fuel used in this case was Ruhr coke varying in size from 10 to 60 mm. (0.4 to 2.4 in.) and containing from 12 to 15 per cent of ash and water. The ash analyzed on the average as follows: SiO_2, 48 per cent; Al_2O_3, 36 per cent; Fe_2O_3, 9 per cent; CaO, 3 per cent; varia, 4 per cent.

The problem was to determine whether the ash-fusion-type gas producer would be made capable of burning fuels other than special lignites.

In the early part of the experimental work considerable difficulty was encountered. The producer ran perfectly well for a few hours at the beginning, the output of gas being plentiful and the gas of high value. There was no trouble with the slag, but at the end of 15 hr. the tuyeres became coated with heavy layers of dense deposits which no effort succeeded in dislodging. Gradually the sticky mass invaded the whole interior of the gas producer, the blast pressure had to be increased, the output of gas fell off, and the slag refused to run out. It then became necessary to stop and clean the producer, not an attractive job as the mass formed inside was very hard.

An analysis of conditions of operation and processes inside the gas producer led to the belief that the trouble was due to premature melting of the slags and coke ashes. As a matter of fact, simple calculation would indicate that the temperature resulting from the conversion into carbon monoxide of 75 per cent of carbon mixed with 25 per cent of inert matter must exceed 1600 deg. cent. (2912 deg. fahr.).

This temperature, under the conditions of operation then prevailing, was rapidly reached in the zone of the tuyeres. It extended progressively to the upper layers and made the ashes sticky. The charge was interfered with in its downward movement and the air blast encountered coke mixed with pasty slag, trouble resulting.

In the blast furnace, where some of the conditions of operation are very similar to those of the ash-fusion-type gas producer, this kind of trouble is not encountered as a rule because the excess of heat developed by the combustion of fuel is absorbed in the reduction of the ore. This led to the conclusion that it was necessary to make the gas producer similar to the blast furnace in this respect by giving it something to reduce, and water vapor was selected for this purpose, partly because it was easy to regulate the amount of its admission and also because the hydrogen produced by dissociation would tend to increase the heating value of the gas.

With this in mind a series of tubes connected to a steam pipe were placed 50 cm. (20 in.) above the blast tuyeres. The results were very satisfactory. The temperature of the ascending current of gases was lowered by the decomposition of the water vapor and the upper layers of the fuel bed ceased to grow pasty. This process was patented in Germany. Gas analysis served as a basis for determining the amount of vapor that had to be injected. In actual practice the following procedure is used: After the producer has been started up, the steam valve is gradually opened until the content of carbon dioxide in the gas reaches from $1^1/_2$ to 2 per cent. It has been found that under these conditions the steam is practically entirely decomposed, the preliminary fusion of the slag eliminated, and the heating value of the gas brought up to maximum. The dissociation of the steam absorbs approximately one-third of the heat developed by the combustion of the coke and the gas shows the following composition having a heating value of 1140 to 1200 cal.: Carbon monoxide, 31 to 32 per cent; H_2, 6 to 8 per cent; carbon dioxide 1.5 to 2 per cent; N_2, 58 to 60 per cent.

This analysis was obtained with coke as fuel, and obviously a different composition of gas would be obtained with fuel containing volatile constituents.

As soon as the part played by the injection of steam and the method of using it have been established, it becomes fairly easy to determine by trial the proper blast pressure, the diameter of the tuyeres, and the thickness of the bed necessary to secure the best operation of the producer. The following are the results which the author claims to have obtained: The quantity of coke gasified in 24 hr. was from 50 to 55 metric tons (55 to 60.5 short tons); this may be lowered to 35 metric tons (38.5 short tons) without trouble, but if the output is reduced still further the flow of slag becomes excessively sluggish. The normal operation apparently corresponds to a combustion of 1100 kg. of coke per hr. per sq. meter of surface of the hearth (225 lb. per sq. ft.).

At first broken limestone was added as flux, but when the lumps were of a certain size not enough time was available for them to act with the silica in the slags and they were usually found at the bottom of the cupola. Because of this granulated blast-furnace slag was tried having the following composition: SiO_2, 30 per cent; Al_2O_3, 15 per cent; CaO, 42 per cent; MgO, 6 per cent; Fe_2O_3 and MnO, 7 per cent.

It is not enough, however, to add the quantities theoretically necessary to obtain with the slags a product fusible at the temperature prevailing in the fuel bed; it proved to be necessary to add quantities up to 10 or 12 per cent of the weight of the fuel, this excess being necessary to produce a sufficient quantity of heat in the hearth part of the furnace, the gas producer not having a metallic bath with a large reserve of heat like the blast furnace.

Analysis of the slag formed in the producer showed it to have the following average composition: SiO_2, 38 per cent; Al_2O_3, 26 per cent; CaO, 32 per cent; MgO, 2 per cent; Fe_2O_3, 1 per cent; and MnO, 1 per cent. This slag comes out with a temperature of 1500 to 1600 deg. cent. (2732 to 2912 deg. fahr.) and gives a very light product on granulation. In addition to the slag, there issues a highly silicious pig iron from the iron contained in the ashes and flux.

Later on the blast-furnace slag was replaced by slag coming from the producer itself to which was added finely broken limestone, the purpose of which was to maintain a constant composition of the fuel bed. The air of combustion is blown in through eight tuyeres under a pressure of 800 to 1000 mm. (31.5 to 39.37 in.) of water and a temperature of about 250 deg. cent. (482 deg. fahr.). The heating of the air is not absolutely necessary, at least for some fuels, and one of the later installations made by the author has operated for several months with cold air. The author found, however, that the tapping of the slag, which is a good deal colder with cold air blast, is apt to give trouble once in a while, and that it is of advantage to heat the air to as high a temperature as possible. The heat brought in by the hot air increases the temperature in the zone of fusion and hence the temperature of the slag; it also permits the injection of more water vapor, thus increasing the heating value of the gas. This again results in a higher efficiency where the gases are not used directly as they leave the gas producer. The sensible heat of the gases, which on issuing from the producer have a temperature of 550 to 800 deg. cent. (1022 to 1472 deg. fahr.) in accordance with the humidity and the physical properties of the coke, may be employed to preheat the air, as the author has done in the majority of his installations, and may also be used to generate steam for injection purposes.

As regards dust content of the gas, it is much higher than that obtained in slow-running producers, but the quantities of dust are not very large where the fuels and flux used do not themselves contain large amounts of dust. In general, there was no trouble in cleaning a gas until it contained not more than 0.02 gram per cu. m. (0.0087 grains per cu. ft.) of dust.

The operation of the gas producer is cheap and very simple. It is limited to charging the fuel every 12 to 15 min. and tapping the slag every 2 hr. It is not necessary to clean the walls as the fuel does not stick to them. The maintenance charges are limited to repairs of the hearth and boshes once every six to eight months. The renewal of the brickwork takes about a week. The trough lining lasts for years.

The author gives a heat balance of the ash-fusion producers from which he derives a thermal efficiency of 77 per cent. He claims to have obtained these results with Ruhr coke in installations gasifying up to 70 metric tons (77 short tons) per unit.

In the discussion which followed M. Hock pointed out that the great value of the ash-fusion gas producer lies in its ability to handle not only fuels with a very high content of ash but fuel containing materials which hitherto have not been really considered as fuels at all. Another advantage of this procedure is its continuous operation. (Paper before the Scientific Congress of the Association of Engineering Alumni of the Liège School, abstracted through *Revue Universelle des Mines*, 6th series, vol. 18, no. 4, Aug. 15, 1923, pp. 251–260, *dA*)

[Ash from most coals contains small amounts of iron as shown by the production of pig iron from ash-fusion gas producers mentioned in the paper of Servais abstracted above. This fact is taken advantage of in a recently developed process of recovery of unconsumed fuel from ashes by magnetic separation (Germany). It appears that as a result of chemical conditions in the fuel bed the iron is present in the ash in the form of magnetic oxide and the ash and cinders are attracted by the magnets of the separator while the unconsumed fuel is not.—EDITOR.]

INTERNAL-COMBUSTION ENGINEERING (See Marine Engineering)

A Water-Cooled Internal-Combustion Turbine

THE PUPLETT INTERNAL-COMBUSTION TURBINE. Description of a turbine invented by T. Puplett, of Manchester, England, in which the difficulty of keeping the parts from overheating is said to be solved by a system of water cooling.

Briefly, the Puplett turbine consists of a heavy cylindrical casing very thoroughly water-jacketed. This casing is held between two water-jacketed side plates drawn together by bolts. Also held between the side plates are two iron rings pierced by inclined ports, and in the narrow space between these rings is a third ring, also ported, and free to rotate through a small angle.

Inside this assembly of rings runs the rotor, a cast-iron wheel 12 in. in diameter with vanes on its periphery. The rotor shaft, of course, is carried in bearings in the end plates.

It will be seen that this construction gives an assembly as follows: an outer casing, an annular space, a fixed ring of ports, a movable ring of ports, another fixed ring of ports, and, finally, a vaned wheel or rotor. The annular space is the combustion chamber, and it may be put into communication with the rotor vanes, or cut off therefrom, by altering the positions of the port rings.

The combustion-chamber is charged with gas drawn into a separate pump cylinder operated by suitable gearing from the rotor shaft. Valves in the turbine back plate allow the pump piston to transfer its charge and compress it into the annular combustion chamber, where it is ignited in the ordinary way by a sparking plug.

At one point of the combustion-chamber wall is a tangentially disposed cylinder which contains a small spring-loaded plunger, connected by a link to a lug on the movable port ring. The expansion of the gas drives the plunger outward, so moving the ring and putting all three rings of ports in the same relative position that the gas is free to pass through and impinge upon the rotor vanes. By a timed eccentric motion the plunger returns when the next charge is ready.

The gas, after doing its main work upon the rotor vanes, finds its way through exhaust holes drilled through the rotor rim toward the center, which is recessed. These exhaust holes are drilled in such a manner as to take advantage of whatever velocity remains in the gas. Holes are drilled in the web of the rotor, and the exhaust gas escapes through ports in either one or both of the side plates of the machine. Exhaust gas is prevented from reaching the shaft by spring-loaded rings carried in grooves in the rotor boss, which is also drilled parallel with the shaft axis so that air can circulate.

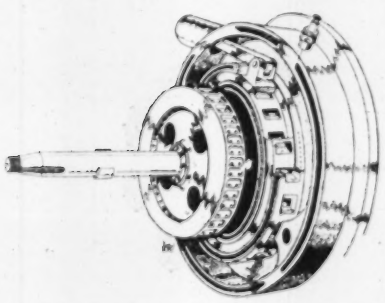


FIG. 2 PUPLETT INTERNAL-COMBUSTION TURBINE. PART SECTIONAL VIEW SHOWING THE THREE RINGS OF PORTS AND THE ROTOR

(The middle ring of ports is movable and is controlled by a spring-loaded plunger in a small cylinder set at a tangent to the casing.)

Naturally, the internal heat of this machine would quickly render it unworkable unless special precautions were taken. The water jacketing of the outer casing and end plates presents no difficulty, and the problem is the cooling of the enclosed ports. This is done very simply by putting an annular groove in each edge of the two fixed port rings and then drilling through from one side to the other in the solid metal between every port. There are fifteen ports and fifteen water spaces, therefore, in each ring.

Oil grooves are machined on the contact faces of the port rings, and lubrication may be by oil spray from the combustion-chamber walls, by ducts through the end plates, or by admixture of oil with the gasoline. The port-ring movement, however, is very slight, and there are no other parts requiring lubrication except the shaft bearings, which are fed from oil holes in the shaft.

The turbine is intended to be worked in tandem, two or more complete units on the one shaft, so that there shall be no noticeable unevenness of torque due to the "dead" intervals while the combustion chamber is being charged. In the smaller sizes, at any rate, it is intended that the charging cylinder shall be annular and located between each turbine unit, the piston being coaxial with the shaft. In bigger plants a separate compressor, driven from the main shaft, would be used. (*The Autocar*, vol. 51, no. 1452, Aug. 17, 1923, p. 281, 1 fig., *d*)

The Revolver-Type Internal-Combustion Engine

THE REVOLVER-TYPE ENGINE. Description of a French design which constitutes a revival of a comparatively old idea.

The revolver-type engine was tried unsuccessfully in France ten years ago. Recently, however, Edouard Laage, an aviator, produced such an engine of 300 hp. with 16 cylinders arranged in two horizontally opposed rings of eight each. The arrangement of the cylinders is similar to the magazine of a revolver and it is possible to make the engine either as a rotary unit or with the cylinders stationary.

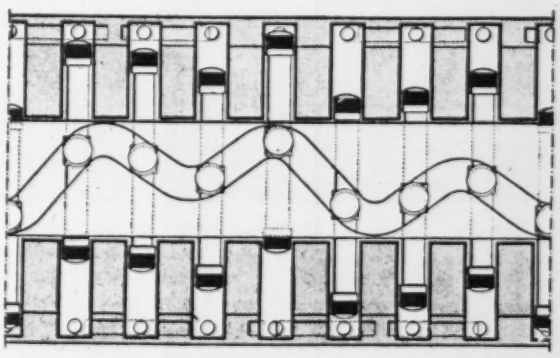


FIG. 3 DEVELOPMENT DIAGRAM OF CAM PATH, SHOWING THE CYCLE OF OPERATIONS WHICH IS COMPLETED IN ONE REVOLUTION

(From left to right the cycle of operations shown in the diagram is as follows for the top line of cylinders: induction, compression, power stroke, exhaust, scavenging. The same series occurs in the opposed cylinders.)

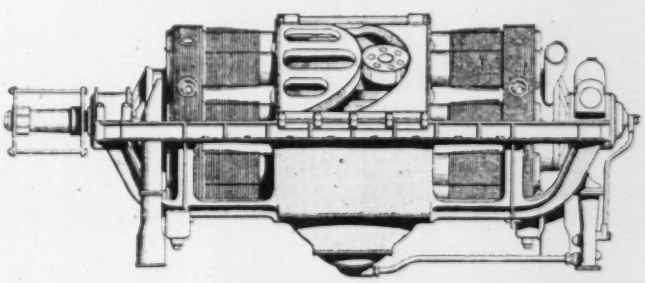


FIG. 4 GENERAL VIEW OF ENGINE, WITH TOP HALF OF COVER REMOVED, SHOWING ONE OF THE ROLLERS WHICH TRAVEL IN THE STATIONARY CAM PATH

(Each pair of horizontally opposed cylinders acts on this cam path through connected pistons and rollers.)

The relative reciprocating movement of cylinders with pistons (Fig. 3) is secured by a kind of double cam cut right around the cylindrical portion of the engine which joins the two sets of horizontally opposed cylinders and might be called a crankcase but for the fact that it has no cranks inside it. In the sinuous path thus formed rollers are constrained to travel, there being a pair of these for each pair of horizontally opposed cylinders.

There is one very important point which should now be noticed. The sinuous track in which the rollers work, and which imparts movements of reciprocation to the pistons in the cylinders, can be formed in any way that may be desired, whereas with the ordinary crank and connecting-rod arrangement the only variation that can be obtained in the cycle of operations is the small one that can be secured by offsetting the crankshaft. In the revolver type, however, any desired cycle of piston movement can be obtained simply by varying the form of the path which the rollers follow, and in the example that has been constructed in France a six-stroke cycle has been adopted between exhaust and induction. The induction and compression strokes are only half the length of the subsequent power stroke, so that the utmost advantage is taken of expansion—an advantage analogous to that of the compound steam engine over the

simple. (*The Autocar*, vol. 51, no. 1450, Aug. 3, 1923, p. 189, 2 figs., *d*)

MACHINE PARTS

Research on Ball Bearings, H. G. Freeland. The author formulates a series of questions on ball bearings and gives answers to them. From these questions it would appear that the cause of failure of bearings is more often to be found in the races than in the balls, and that the inner race is more susceptible to failure than the outer.

The cause of ball failure in at least 90 per cent of the cases is to be found in surface defects, such as seams, most of which originate in the steel mills. There are no steel mills which can as yet supply on a commercial basis drawn wire rod or hot-rolled stock entirely free from such defects as rolling laps, seams, decarburization, etc. The process of manufacture of balls is of less importance than the freedom of the steel from defects, particularly those on or near the surface. The author considers pressed and forged balls superior to turned balls.

It does not appear that any reduction of size takes place as a result of operation of balls if free from dirt and correctly lubricated. (*Automotive Industries*, vol. 49, no. 8, Aug. 23, 1923, pp. 368–369, *gp*)

Steel Conveyor Belt at a Stone-Pulverizing Plant, Geo. M. Earnshaw. Data on an installation of the Waukesha Lime & Stone Co. at Waukesha, Wis., in which a steel conveyor connects the crushing and pulverizing plants and special bin gates are provided for feeding the stone to it in the crushing plant.

The belt is of 178 ft. centers, is 16 in. wide and 0.035 in. thick. Because of the exactness required in jointing the belt, the installation was carried out by the Sandvik Steel Service Department. The joint is, however, a common lap fastened together by countersunk rivets.

At present the belt handles the product of one pulverator which gives 30 tons per hour. Plans have been drawn up for the installation of a second pulverator which will double the output. Because of the fact that the rate of delivery per hour at the discharge end is governed by the maximum capacity of the pulverator while the length of the belt is fixed, a speed of 100 ft. per min. had to be used. This speed is, however, a very slow speed for these belts to operate, the usual speed being 200 ft. per min., while in some installations 300 ft. per min. has been found possible. Because of this, when the second pulverator is installed the carrying capacity of the belt can be doubled by merely changing the driving pulley.

According to the statement of the manager of the plant, the belt is free from vibration, runs flat, requires less power than other belts in the plant carrying less material, and has never given any trouble.

According to author, who is associate editor of *Rock Products*, there are now in existence three steel-belt installations in rock-product plants: namely, the one already described, one at the Michigan Portland Cement Co., Chelsea, Mich., and the one at Penn-Allen Cement Co., Penn Allen, Pa. (*Rock Products*, vol. 26, no. 17, Aug. 25, 1923, pp. 37–40, 11 figs., *d*)

MARINE ENGINEERING

Cost of Converting a Steamship to Diesel Power

Cost of Converting to Diesel Power an 8000-Ton Shipping Board Ship, Louis R. Ford, Mem. A.S.M.E. A discussion of the probable cost of conversion of one class of Shipping Board vessels. Only some of the features can be reported here.

In considering this question of power, it should be borne in mind that a Diesel engine will sustain its rated power continuously, day after day, whereas a steam plant is subject to wide variations and seldom maintains its designed power for very long intervals. This means that on the average voyage it is not necessary that the rated Diesel power be as great as the rated steam power to enable a vessel to complete the voyage in the same length of time. When converting a 10-knot vessel with 2500 steam hp., a 2000-b.hp. Diesel engine, which would drive the ship a 9.2 knots, should be sufficient if equal results as to time of passage on moderately long voyages is desired. If a special machinery arrangement such as Diesel-electric drive or geared drive is desired, dimensional limitations will have less influence in deciding the horsepower that can be used. For the purposes of this discussion, we will assume that a 2000-b.hp. four-cycle engine is to be used, direct-connected to the propeller shaft.

The next step is to consider the type, number, and size of auxiliaries to be used. One of the most vexing questions involved in the consideration of a conversion job is whether the steam deck winches shall be retained or be replaced by electric winches. From the operating point of view unquestionable the most satisfactory arrangement is to completely eliminate all steam auxiliaries throughout the vessel. Electrically operated auxiliaries have become standardized to the extent that today steam auxiliaries on a motorship are about as acceptable as tan shoes with a dress suit, and no one would consider building a new general-cargo motorship without electrical auxiliaries.

On account of consideration of investment cost and fixed charges it may be desirable to retain the steam cargo winches already available on the ships. Since sufficient boiler power to operate the deck winches must be available and since such auxiliaries as steam-driven condenser circulating pump; boiler-feed pump; boiler oil-feed pumps, sanitary pumps, fresh-water pumps, fire and bilge pumps, and electric-lighting generators are also available, it may be desirable to retain the steam drive for all of them, though electrically operated auxiliaries may be more economical.

A good compromise may be arrived at by installing electrically operated engine-room auxiliaries and an electrically operated steering engine for use at sea, with sufficient Diesel-electric generator capacity to furnish them with current, and retain such of the existing steam auxiliaries as are needed for operation in port. With this arrangement the operating procedure would be to allow steam to die out at sea and operate the ship purely as a motorship with electric auxiliaries, and, upon arrival in port, raise steam in the boiler and shut down both the main and auxiliary Diesel engines. The auxiliary air compressor should be steam-driven. A reduction in first cost is thus obtained, and ample assurance against breakdown is provided. The only time this auxiliary compressor will be required for pumping up starting air is when entering or leaving port or shifting berth, at which times the boiler will be under steam. The principal classification societies have ruled that such a steam-operated compressor arrangement will be approved by them.

The boiler system is discussed next and it is proposed to retain one of the existing boilers, provided it is in good condition, and utilize for the heating of living quarters a small steam boiler through which the exhaust gases from the engine may be passed when necessary.

The article gives a tabulation of the equipment to be retained and new equipment to be purchased, the latter amounting to $213,078, which is, by the way, several times the price of the unconverted vessel if bought from the Shipping Board.

Assuming that the steamer may be purchased from the Shipping Board for $6 per deadweight ton, one can now estimate the total cost of conversion to a motorship as follows:

Cost of steamer	$ 52,800 00
Cost of new machinery	213,078 00
Cost of shipyard work	80,000 00
Total cost of conversion	$345,878 00
Cost per deadweight ton	$39 to $40

Since the low price level of good steamers is about $30 per deadweight ton, and for European-built motorships probably not less than $60, it would seem that the converted Shipping Board vessel at $40 per deadweight ton should be in an advantageous position in competition with either. Its superior fuel economy should more than overcome the steamer's advantage in fixed charges, and in comparison with the European motorship its smaller fixed charges should overcome the latter's advantage as regards operating costs.

The original article contains two figures—one showing the engine-room machinery arrangement for a conversion plan in which no steam auxiliaries are used, and the other the compromise arrangement whereby steam auxiliaries may be used in port and only electric auxiliaries at sea. (*Motorship*, vol. 8, no. 9, Sept., 1923, pp. 620–623 and 649, 2 figs., *p*)

MEASURING INSTRUMENTS

THE RECORDING ULTRAMICROMETER, John J. Dowling. Description of an apparatus based on an electric-valve method for measuring small capacity variations and which differs in principle from a similar apparatus developed by Professor Whiddington and described in MECHANICAL ENGINEERING, vol. 43, Jan., 1921, p. 49. It is claimed that the apparatus under consideration is less complicated, in addition to which it permits recording measurements which Whiddington's apparatus does not.

The article describes in detail the electrical features involved in the design of the apparatus. This part cannot be abstracted because of lack of space.

The recording ultramicrometer may be applied to the determination of minute displacements, changes of length, and the like, and it is claimed that no very delicate adjustments need be provided for the condenser plates. An important application of the device is in the construction of an extensimeter. According to Ewing, it is desirable with an 8-in. specimen to read the extension within one fifty-thousandth of an inch or to within two-millionths of a centimeter per centimeter length. With the present apparatus this amount can be easily recorded on a specimen even 1 in. long, and furthermore the lateral strain may also be recorded and thus may be determined Poisson's ratio and hence all the elastic constants on even quite small specimens.

The apparatus responds to rapid variations of the observed phenomena. The author describes the use of the device to record minute flexure of the diaphragm of a pressure gage in which it gave some unusually interesting results. (*London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, vol. 46, no. 271, July, 1923, pp. 81–100, 9 figs., *dA*)

METALLURGY (See Engineering Materials; Special Processes)

MOTOR-CAR ENGINEERING

THE LAGONDA CAR. One of the unique features in the construction of this car is the chassis, or rather lack of it in the usually accepted sense of the term. The pressed-steel members of the body take the load of the engine and transmission gear and are mounted directly on the springs, which are designed especially for the job. Quarter-elliptic rear springs and a specially designed transverse front spring support the vehicle on the road wheels, and as regards the front transverse spring a special arrangement of linkage and anchorage is designed which effectually does away with any tendency to rolling.

The oil for the shaft, big ends, little ends, and the exhaust and inlet valve gears is circulated by a rotary pump driven off the camshaft. This is a new development and takes the place of the outside plunger pump driven by a disk and crankpin which was fitted to the previous model. It makes a neater and a more effective arrangement, and one quite immune from any possibility of derangement.

The oil is lifted from a strainer chamber in the sump and delivered under pressure to the main bearings direct and to the overhead valve motion, the side camshaft, and the silent-chain distribution gear.

Troughs are arranged in the under part of the aluminum crankcase, into which the big ends of the connecting rods dip. These troughs are kept supplied by the pump, and dippers on the big ends not only insure adequate lubrication of these important bearings, but also splash up the oil for the cylinder walls and little ends. A lead running from the pump takes the oil up to the rocker arms above the inlet valves and lubricates the rocker and push-rod mechanism.

It will be seen, therefore, that the lubrication system is automatic and self-contained. The overhead inlet valve gear is fully protected and enclosed, and the leakage of oil prevented by the well-fitting and very neat aluminum cover which encloses it, and which can be quickly and easily removed by undoing the two wing nuts which hold it down on its oil-tight sealing joint. (*Auto-Motor Journal*, vol. 28, no. 32/1179, Aug. 9, 1923, pp. 661–664, 10 figs., *d*)

POWER-PLANT ENGINEERING

Reduction of Leaving Losses in Steam Turbines

DEVICES TO REDUCE LEAVING LOSSES IN STEAM TURBINES, Ivor R. Cox. The author briefly discusses the theory underlying the difficulty with losses in the last row of blades. This is well known and therefore is not abstracted.

The first and obvious method of obtaining greater leaving area is by increasing the mean diameter of the last stage without decreasing the height of the last row of blades. The question of excessive stresses and vibration puts a limit in this direction, however.

Instead of the parallel blade, another way is to use a blade the section of which is larger at the root than at the tip, such as taper blades or blades widened toward the root. By suitable thickening and widening o :the blades and without increasing stresses it is possible to increase the leaving area by approximately one hundred per cent.

The author shows a design where increased leaving area is obtained by the use of a very large disk in the last stage but at the expense of the safety in this stage. With turbines of the reaction type the double-flow arrangement may help. With the two-cylinder design (cylinders arranged in tandem) which is now practically standard in England for axial-flow reaction turbines of large outputs, the low-pressure cylinder only is made double-flow.

Another way of obtaining increased leaving area is by having more than one "last row" of blades without departing from the single-cylinder design. One of the earliest arrangements of that kind, illustrated in the original article, was devised by Delaporte, who suggested the use of two condensers.

A part of the steam flowing through the turbine is taken to the first condenser from immediately before the last stage, the vacuum in this condenser being relatively low. The remainder of the steam flows through the last stage and exhausts to the second condenser, in which a high vacuum is maintained. The circulating water flows first through the condenser giving the higher vacuums, and then through the other, the primary object of the invention being to obtain increased output with the same quantity and temperature of circulating water. The arrangement is, in addition, well suited to reduce leaving losses when these are high, as the steam velocity leaving the last row of blades is much reduced owing to the reduction in steam quantity consequent on exhausting a portion of the steam at the last stage but one to a second condenser, the vacuum of which may be arranged to correspond with the required design pressure in front of the last stage.

Another illustration shows a type of exhaust end with a continental design of turbine, the double-flow arrangement being employed in the last stage only. This arrangement is not described as it has obvious disadvantages.

A third method for obtaining double leaving area without reversing the general axial direction of flow of steam is contained in Guy's British patent (No. 14596, year 1915). Here, near the last stage, by means of a specially shaped diaphragm, steam is diverted into two annular portions. There are two similar "last stages" through which the steam is exhausted to the condenser in parallel streams. It is of course also possible to divide the steam into two portions earlier in the expansion.

From this the author proceeds to the description of the multi-exhaust construction invented by Baumann (compare MECHANICAL ENGINEERING, vol. 45, no. 7, July, 1923, pp. 430–431).

The use of a diffuser for decreasing leaving losses, which was at one time fairly common, particularly with radial-flow machines, has fallen into disuse as the actual improvement in steam consumption is small.

In recent years feed heating by extracting low-pressure steam from the turbine has proved beneficial in improving the economy in power-station work, and the author discusses this feature of design in some detail. He claims that feed heating also acts as a device for reducing leaving losses.

A certain amount of steam is bled at, say, a low-pressure stage for feed-heating purposes. This steam does not therefore pass through the last stage of the turbine, the leaving velocity is thereby lowered, and the leaving losses decreased. In a particular case, with a 10,000-kw. turbine, the leaving and exhaust loss, when working without feed heating, is 4 per cent. By tapping a low-

pressure stage the feedwater temperature is brought up from, say, 70 deg. to 170 deg. fahr. The approximate reduction in steam quantity passing through the last stage is some 8 per cent, so that the leaving and exhaust loss is reduced by 15 per cent, which is equivalent to a gain of approximately 0.6 per cent on the overall turbine efficiency. When the feedwater is raised to a higher temperature than in this example, the reduction in leaving and exhaust loss is still more. Thus, in a particular case known to the writer, the final feed temperature is 300 deg. fahr., the decrease in steam quantity flowing through the turbine exhaust, as compared with no feed heating, is 20 per cent, and the decrease in leaving and exhaust loss no less than 35 per cent.

The other loss occasioned at the exhaust end of the turbine is that due to the velocity of the steam through the actual exhaust passage. This loss, in general, is small compared with the leaving loss, as it is comparatively easy to provide a reasonably large exhaust area. For maximum efficiency the steam should travel by easy paths properly guided from the last row, or rows, of blades to the condenser. In such an exhaust it can be taken that the loss, as measured by the drop in pressure, is equal to the head corresponding to the exhaust velocity. We have seen that the leaving loss L is given by

$$L = \frac{V^2}{2\,gJ}$$

Similarly the exhaust loss E is given by

$$E = \frac{X^2}{2\,gJ}$$

where X = steam velocity in the turbine exhaust, i.e.,

$$E \text{ (expressed as a percentage)} = \left(\frac{X}{224}\right)^2 \times \frac{100}{i}$$

$$\therefore L + E = \frac{100}{i}\left\{\left(\frac{V}{224}\right)^2 + \left(\frac{X}{224}\right)^2\right\}$$

$$= \frac{100}{i}\left(\frac{Z}{224}\right)^2$$

where Z is that velocity which gives the same total loss as the leaving loss and the exhaust loss.

This enables us to deal with the combined leaving and exhaust losses by imagining an area called the "equivalent exhaust area," which is such an area that the steam at exhaust pressure flowing through it would occasion a loss equal to the sum of the leaving and exhaust losses. Thus, if A_z = equivalent exhaust area, A_v = leaving area, and A_x = exhaust area, as $V^2 + X^2 = Z^2$,

$$\therefore \frac{1}{A_v^2} + \frac{1}{A_x^2} = \frac{1}{A_z^2}$$

The use of the equivalent exhaust area enables a comparison to be made quickly between differently designed turbines of a given output used under similar steam conditions. (*Beama*, vol. 13, no. 65, Sept., 1923, pp. 175–181, 6 figs., *dc*)

PUMPS

Motor-Operated Centrifugal Pumps in Steel Plants, R. A. Cornwell. In the steel industry one of the most important factors in maintaining production is the efficiency and reliability of the water-supply system. Centrifugal pumps are extensively used and the author considers here the operation of motor-driven pumps as compared with steam-turbine-driven pumps.

As regards cost, it would appear that when delivering water at the rate of 1,250,000 gal. per hr. the cost of pumping 1000 gal. of water per hr. is $0.00238. For the same condition the cost of pumping water by a steam-turbine-driven pump is $0.00288. Similar comparisons are given for the installation costs.

From this the author proceeds to an extended discussion of types of motors for driving centrifugal pumps and some of the features of the electrical installation. (*Association of Iron and Steel Electrical Engineers*, vol. 5, no. 9, Sept., 1923, vol. 309–326, 6 figs., *cp*)

RAILROAD ENGINEERING

The Development of the Continuous Turntable, Otis E. Hovey, Mem. A.S.M.E. A brief criticism of existing types and description of a new design developed by the American Bridge Company.

In this new type the main girders are continuous from end to end and are provided with top and bottom laterals. These main girders are made shallow so that irregularity in the upper surface of the circle rail should not cause material increase in the girder stresses. The attachment of the end trucks to the main girder is so arranged that the reinforced end webs of the main girders rest upon heavy bearing plates on the trucks; furthermore, the arrangement is such that the truck can rock with respect to the girders, thus permitting the wheels to take equal loads from the girders. The entire train of driving mechanism and the brake are mounted on the truck frame.

One of the drawings shows a roller type of center recommended for use under continuous tables, it being claimed that it is more efficient than the usual disk type. The general advantages of continuous type are discussed in detail. (*Railway Age*, vol. 75, no. 7, Aug. 18, 1923, pp. 295–298, 7 figs., *dc*)

REFRIGERATING ENGINEERING (See Testing and Measurements)

SPECIAL PROCESSES

Use of Conditioned and Enriched Air in Gas Producers, Cupolas, and Blast Furnaces

The Use of Preheated, Dry, Moist and Oxygen-Enriched Air in Gas Producers, Cupolas and Blast Furnaces, J. Seigle. The conditions of operation in ordinary furnaces and the three types of apparatus mentioned in the title are radically different in each case. In furnaces the desire is to achieve complete combustion at the required high temperature without inordinate excess of air. In gas producers the aim is to increase the potential heat of the gas and at the same time decrease the heat evolved in the apparatus itself. In cupolas it is to reduce the potential heat in the flue gas so that it will contain as much carbon dioxide as possible and only a little carbon monoxide; furthermore, an effort is made to cause as large an amount of sensible heat to develop in the apparatus as possible, which serves to raise the temperature of the metal and to insure cool gas in the flue. In blast furnaces the aim is roughly the same as in cupolas, namely, to have a gas in the flue with a low potential heat and low sensible heat; to burn as much as possible of the carbon to carbon dioxide in the apparatus, etc.

From this it would appear that the aim of the combustion process in cupolas and blast furnaces is exactly opposite to that in gas producers, so that what would make for good efficiency in one case would be undesirable in another. From this point of view it is rather curious to find that the same means, such as air preheating, air drying or moistening, and oxygen enrichment have been suggested for all three classes of apparatus, i.e., boiler furnaces, gas producers, cupolas and blast furnaces, although the aims of the processes are radically different.

The author discusses the possibility of improvement by these means for each type. In apparatus like boiler furnaces he finds that preheated air improves operation in several ways. For gas producers dried air may be left out of consideration, as a certain amount of water vapor has long been known to improve operation, in particular by making it more regular. Recently Servais at the Metallurgical Congress in Liège mentioned the advantages of the use of water vapor in air in gas producers of the ash-fusion type, where the injection of water vapor prevented clinkering of the bed which otherwise tended to become excessive. In the Mond process water vapor is used to increase the ammonia content in the gas, and finally in the water-gas producer it is an essential element of the process.

Preheating of air has been used in several types of gas producers. It has been particularly useful in ash-fusion-type producers and it has been found, among other things, that the use of preheated air results in the lowering of the temperature of the gas, as a result of which more calories are available in the form of potential heat of

the gas. It would appear that air preheating is very useful in the case of producers.

The author shows by figures that it may be also worth while to use preheated air and water vapor simultaneously.

Oxygen-enriched air has been tried in producers but is not used commercially as yet, the reason probably being that the advantages obtained do not compensate for the higher cost of the process. It is possible that enriched air may be used instead of preheated air in ash-fusion-type producers.

As regards cupolas, the usual process is to use room air. There does not appear to be any good reason to expect material improvement from dry air, and obviously it would be inadvisable to make special additions of water vapor to the air. As far as the author is aware, no attempt has been made to use enriched air, because the advantages are not likely to compensate for the higher cost of the process. Preheated air has been tried, but under ordinary foundry conditions did not give valuable results. It has been found of value in cases where particularly high temperatures of melting were desired, as, for example, in Rollet cupolas for making specially pure iron or in cupolas melting ferrochrome.

In blast furnaces the use of preheated air is well known and the author gives numerical data in this connection. As regards dry air, he refers to Gayley's work, but expresses the opinion that where preheated air is used the additional cost of air drying does not produce improvements sufficient to compensate for it. He discusses to some extent oxygen-enriched air on the basis of the tests at the Ougree plant and gives some interesting data, among other things showing a comparison of the characteristics of exhaust gas from blast furnaces working with ordinary preheated air and with oxygen-enriched air. (*Revue de Métallurgie*, vol. 20, no. 7, July, 1923, pp. 481–489, 1 fig., *cp*)

TESTING AND MEASUREMENTS

NEW STROBOSCOPIC INSTRUMENT FOR STUDYING HIGH-SPEED MOTION. Description of an optical instrument called the Rotostat, which is in principle a motor-driven stroboscope. A hood, fitting the face, is provided, in the front of which is an aperture eclipsed by a pierced shutter. The latter is motor-driven and its speed is controlled by the turning of two knobs, one for coarse and the other for fine adjustments. When the speeds of the shutter and the observed object are exactly equal, the latter appears to stand still. When the shutter runs faster or slower, the object appears to move at a rate equal to the difference in speeds. The apparatus works from a 110-volt lighting circuit and the entire manipulation consists merely of turning the knobs until the desired object speed is obtained. (*Automotive Industries*, vol. 49, no. 11, Sept. 13, 1923, p. 521, 1 fig., *d*)

RELIABILITY OF FLUID METERS IN REFRIGERATING TESTS, L. S. Morse. Data of calibration of a number of meters, from which it would appear that they often give incorrect readings.

The table in the original article shows, for example, the percentage of error of the venturi meter compared with the calibrated receivers. This meter was ordered for flows of from 20 to 35 cu. ft. per hr., corresponding to about 750 to 1310 lb. per hr., but the scale which the manufacturers sent for the manometer was graduated from zero to 5000 lb. The dimensions on the lower part of the scale were very close together and there was but one division $\frac{1}{4}$ in. long from 0 to 500 lb. Consequently any flows below 500 lb. per hr. could not be accurately determined, which accounts for the large errors at these low tonnages where less than 500 lb. was used.

A smaller venturi tube and scale has recently been ordered and with its use it is expected that the error will be reduced for these lower flows.

In the discussion C. H. Smoot, Mem. A.S.M.E., called attention to the fact that The American Society of Mechanical Engineers is contemplating a code involving the use of nozzles for the measurement of fluids and gave some information on this subject. He also criticized, to a certain extent, the method of testing used by the author of the paper in that the fluid meter was used to measure a flow of fluid that was not steady, a purpose for which it is not designed.

Clemens Herschel, the inventor of the venturi water meter, defended the use of this instrument, both by the fact of its extensive use for more than thirty years and by direct proofs such as data contained in paper No. 1744 of The American Society of Mechanical Engineers. He also attacked the methods of computation and calibration used by the author. The other discussions of Mr. Morse's paper, though of interest, cannot be abstracted here owing to lack of space. (*Refrigerating Engineering*, vol. 10, no. 1, July, 1923, original paper pp. 1–10, 5 figs., and discussion pp. 8 and 10–13, *ec*)

THERMODYNAMICS

SPECIFIC HEATS OF GASES AND VAPORS, Aimé Witz. Extensive article giving the history of the investigation of specific heats of gases and a comparison of the values obtained by various investigators, together with a theoretical consideration of the main features of the variation of specific heat with temperature.

The general conclusion to which the author, who is a corresponding member of the French Institute, comes is that the variations of the capacities with temperatures are due primarily to intermolecular work. This conclusion follows in the most direct manner from the fact that the capacity of the monatomic vapor of mercury and of rare gases is independent of the temperature. This has been indicated to a certain extent by the experiments of Pier.

Recent development of the mechanical theory of heat has made it possible to formulate certain hypotheses regarding the properties of gases which appear to be dependent on the nature and constitution of the molecule. This latter, however, is extremely complicated and comparatively little is known about it. The author discusses in particular the data provided by the kinetic theory of gases.

The recent hypotheses dealing with molecular reactions may permit penetrating more deeply into this matter. Already a more complete analysis of phenomena has been made by taking into consideration the degrees of freedom of molecules in their movements of translation, vibration, and rotation, and in addition to this new avenues for research have been opened by the theory of quanta. Bjerrum, Krüger, and others have already entered into this new promising field of research.

In this connection the author calls attention to certain views expressed by Berthelot. From a comparison of the true specific heat of water vapor or carbon dioxide with the heats of their elements, and the fact that there is found at 2000 deg. cent. (3632 deg. fahr.) a notable excess of the former, Berthelot came to the conclusion that this excess of specific heat is due to the existence of a double work.

First there is the work of molecular disaggregation of the composite fluid not accompanied by any change in its chemical composition; this is followed by the work of chemical decomposition correlative to dissociation. The first work corresponds to an increase in potential energy which may be attributed to a change in the number of molecules not accompanied by decomposition (as apparently occurs in chlorine), or to some phenomenon analogous to a dispersion of the constituent parts of the chemical molecules. Berthelot compares this effect to that which precedes the rupture of a metal wire subjected to an increasing tensile stress. This work would permit an explanation of the decrease of the heat of formation of the compound at the higher temperatures. (The heat of formation of water, equal to 58,700 cal. at zero, falls off to 37,100 cal. at 4000 deg. cent. (7232 deg. fahr.).)

In citing the views of Berthelot together with certain other theories the author is careful to point out that all these hypotheses are still unproved and that the only way to obtain exact information on specific heats of gases and vapors lies through experimental determinations. (*Revue Générale des Sciences*, vol. 34, no. 14, July 30, 1923, pp. 425–435, *hp*.1)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

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Coöperation of A.S.M.E. in Industrial Mobilization

FOR the first time in its history the United States of America by formal act of Congress has authorized the preparation of adequate plans for mobilizing industry for war emergency, and further has definitely designated a specific individual, the Assistant Secretary of War, as the person responsible for the provision of war essentials and the development of a suitable industrial organization to function during a war period. The National Defense Act, as amended June 4, 1920, which embodies these provisions, is proof that the United States learned its lesson from the recent war. No country, however rich in brains and money, can solve the war problems of design and procurement quickly and economically under conditions of war stress. The "highly complex matérial" demanded by a war machine and the correspondingly "highly organized industrial effort" are problems that require the coöperation of the entire people. All this is definitely pointed out and emphasized by General Williams in his article in this issue on mobilizing industry for ordnance production.

The heaviest responsibility for coöperation in industrial preparedness rests on the manufacturers and engineers who are daily solving production and distribution problems. To these men we especially commend the appeal of the Secretary of War for careful consideration of the preparedness plans.

In publishing this article by General Williams, which has the commendation of the Secretary of War and the approval of the Assistant Secretary, The American Society of Mechanical Engineers is proceeding in its consistent policy of wholehearted coöperation with the Government by enlisting the services and interest of its members in public problems. The Ordnance Division and the Secretary of the Society have intimate contact with the War Department, and as plans develop to the point where specific tasks can be assigned, individual members of the Society will be called upon to assist. As President Harrington points out in his letter on page 628 of this issue, the "plan of avoiding the belligerent attitude and the economic waste of men and means involved in a standing army, while keeping fit to meet effectively any emergency, is sound and in full accord with American ideals."

CALVIN W. RICE.[1]

[1] Secretary, The American Society of Mechanical Engineers.

Engineering Education Hampered by New York Licensing Law

THE licensing law of the State of New York which recently went into effect has brought about a peculiar situation which discriminates against students of engineering. The state awards five scholarships in each county which entitle the holders to one hundred dollars a year for four years while in attendance at a college approved by the state. These scholarships are awarded on the basis of merit. The law stipulates, however, that while the person entitled to the scholarship is not restricted in the choice of the college or in the course of study, the scholarships shall not pay for instruction in theology or in any profession, admission to the practice of which requires a license from the state. On August 1 the New York State law requiring engineers to have a license in order to practice engineering went into effect, hence students electing engineering courses are now unable to receive the benefit of the state award.

Unlike the other professions where graduate courses are generally implied, the prospective engineer necessarily begins his engineering studies in his undergraduate course, the strictly professional training being usually obtained in practice rather than in graduate schools. The result of the present law is an unjust discrimination against engineering education, and already hardships have been imposed upon students who have chosen engineering as a life work.

The engineering societies have a definite responsibility to change this situation, and to do so they will require the assistance of every individual in the profession.

W. H. KENERSON.[1]

Measurement

PROGRESSIVE changes in any science may be illuminatingly studied by following the development of the instruments and apparatus for measurement used in its field, inasmuch as progress in discovery is the direct result of improvement of measuring devices. The march of improvement in machine production from the early days of the nineteenth century, when each mechanic made his own foot rule, is a direct reflection of the improvement in linear and angular measurement. Today an accuracy of one in forty thousand is ordinary practice.

Management entered the realm of science when engineers began to segregate the factors of production and measured them. Time study, methods of wage payment, machine idleness, etc. have been segregated and are now measured. Professor Roe in his paper in this issue applies the methods of engineering measurement to the measurable factors of management by comparison with practical standards, and suggests a general method of comparison between its performances at different periods. Very wisely Professor Roe recognizes that many factors evade the possibility of measurement and judgment must prevail.

Preliminary plans for Management Week reflect the wide interest that is being taken in the measurement of management, and it is safe to prophesy that the discussion of the papers to be presented at the various meetings will do much to define the methods which should be employed for that purpose. These may serve at the beginning—as the first foot rules—until better instruments are devised.

An interesting and exceedingly valuable method for measuring one of the economic factors has been contributed by the Materials Handling Division in its Formula for Computing Economies of Labor-Saving Equipment which appeared in the September issue of MECHANICAL ENGINEERING. This formula merits the attention of every industrial engineer and executive, for it covers in simple form all of the elements which must be taken into consideration in installing new equipment of any kind. Its application is not limited to material-handling equipment. The principle involved applies equally well to all production equipment, and in deciding upon whether a new machine tool should be installed, the formula may be used with very slight modification.

Engineers are particularly fitted to devise such measuring instruments for solving the problems of industry, and it is safe to say that their profession is on the verge of great contribution in its field.

[1] Professor of Mechanical Engineering, Brown University, Chairman A.S.M.E. Committee on Relations with Colleges.

A.S.M.E. Annual Meeting, December 3 to 6

THE strong technical program to be carried out at the coming Annual Meeting of the A.S.M.E. and the 1923 Power Exposition make a combined attraction that should insure a large attendance in New York City at both events during the first week of December. The forty-fourth Annual Meeting of the American Society of Mechanical Engineers will open on Monday, December 3. The meeting will last for four days and will be made up of eighteen sessions covering the various branches of mechanical engineering. This year the Power Exposition will parallel the meeting. However, the meeting sessions of interest to engineers in power work will be scheduled for the morning hours and as the Power Exposition does not open until one o'clock each day, no conflict is anticipated. Last year over forty-seven thousand engineers visited the Exposition. This December the floor space devoted to exhibits will be approximately fifty per cent larger, and their variety is to be greatly augmented. Members of the A.S.M.E. will be admitted to the Exposition upon showing their Society badges or membership cards.

As a topic of general engineering interest the Annual Meeting will emphasize the fundamentals upon which hydroelectric development must be based. One evening session will be devoted to this subject, and the American Society of Civil Engineers and the American Institute of Electrical Engineers are cooperating in the preparation of the program. Mr. John R. Freeman, Past-President of both the A.S.C.E. and the A.S.M.E., will open the meeting and his address will be discussed by representatives of the three engineering societies.

There will also be a joint session with the American Society of Refrigerating Engineers.

The Professional Divisions on Aeronautics, Forest Products, Fuels, Gas Power, Machine Shop Practice, Management, Materials Handling, Ordnance, Railroads, and Textiles will be represented on the program. The Power Test Codes Committee will hold a public hearing and the Research Committee on Fluid Meters will present a portion of its report for public discussion. The Research Committee on Steam Tables will hold a public meeting to discuss progress in the research, and the Committee on Education and Training for the Industries will hold a conference for the discussion of problems of industrial education.

The November 7 issue of the *A.S.M.E. News* will contain the complete program with the list of papers and authors. The Committee on Meetings and Program has decided to confine preliminary publicity about the meeting to the *A.S.M.E. News*. Special circulars about the meeting will not be sent out and members are counseled, therefore, to consult the *A.S.M.E. News* for meeting announcements.

All in Six Weeks

IN THE last six weeks several notable events have occurred illustrating the rapid progress of engineering in this country of ours.

On September 7 a novel type of prime mover was set up commercially for the first time in the central station of the Hartford, Conn., Power and Light Co., which promises to prove of great interest to the engineering world. This is a mercury boiler and turbine developed by W. L. R. Emmett, Mem. A.S.M.E., of the General Electric Co. The principle of the invention is fairly well known. Advantage is taken of the fact that mercury boils at a very much higher temperature than water, and the plant is really a combination of two parallel systems—mercury and steam. The mercury vapor generated in the boiler is first used to drive a turbine, after which it is condensed in a water-cooled condenser and then returned to the boiler. In condensing, the mercury converts the cooling water into steam, which is then superheated and delivered to a conventional steam turbine. The experimental unit was completed in 1913 and it took ten years of work (including the serious interruption caused by war conditions) to solve the numerous problems of design, in particular those dealing with the prevention of mercury leaks. From all indications it would appear that the plant is very efficient as regards the conversion of the latent heat of the fuel into power. The new installation, representing a unit of several thousand kilowatts, may be expected to contribute materially toward the determination of the commercial features of the combination plant.

The seaplane races in England in which American machines carried off the first and second prizes, the International Air Meet at St. Louis, Mo., and the preliminary elimination trials in this country for the two events, have thrown a remarkable amount of light on the progress of aeronautics in general, and American progress in particular, in the last few years. Speeds in excess of 230 miles per hour have been quickly attained and at St. Louis were maintained over a distance of something like 150 miles. To understand the great progress represented in such a trial it should be borne in mind that the attainment of such truly terrific speeds represents not merely an engine problem but an all-round engineering achievement. The progress of a heavy machine through the air at a speed of one-quarter that of sound would impose on the entire structure enormous stresses even if it took place in still air, and the air is never still for a big body like an airplane moving through it at these speeds.

It would be no exaggeration to say that the difficulties encountered by a designer of airplanes increase approximately as the cube, and possibly the fourth power, of the speed. The significance of this will be realized all the better by noting that in none of the recent speed trials has there been an accident involving loss of life or serious injury to the fliers.

The increase in our knowledge of aeronautics and methods of construction of airplanes has found expression in another direction, namely, the successful completion at McCook Field, by the Air Service, War Department, of the giant Barling bomber. Here again the difficulties of design rapidly increased with the size, and while huge machines like the Sikowski, Caproni, and—in this country—Martin bombers have been built before, each one failed, while the Barling appears to be quite maneuverable and has already successfully covered the distance from Dayton, Ohio, to St. Louis, Mo.

The bombing tests carried out off the coast of Virginia have probably not settled the question as to the extent to which an airplane endangers modern battleships. The fact remains, however, that both the *Virginia* and the *New Jersey*, two battleships which were scrapped under the Washington agreement as to limitation of naval armaments, have been sunk by aerial bombs. This has been taken by the Navy as showing the importance of aerial protection for battleships, probably parallel to the protection by destroyers from submarines and mines, the necessity for which has been recognized for a long time. The same tests, though with aerial maneuvers previously executed, have shown that in the first place a new and powerful weapon of naval combat has been recently created in this country, and second, that even with the existing facilities any point on the Atlantic seacoast can be given aircraft protection within seven hours from the appearance of danger, and that aircraft can operate over considerable distances out at sea from emergency hangars on shore.

The commissioning of the *Colorado* represents a notable achievement of American marine engineering. It is a superdreadnaught of 32,600 tons displacement with two 18,000-hp. turbo-electric generators delivering power to four 8000-hp. electric propeller motors. This arrangement of steam-turbine electric-propeller drive has been developed in this country and more widely adopted in the American Navy than anywhere else. Its armament of eight 16-in. guns in two forward and after turrets is the largest permitted under the Washington conference, and as long as the limitations of this conference stand the *Colorado* may be said to represent the last word in battleship construction.

We think of ourselves as young industrially, and yet the country has reached an age where anniversaries of its achievements in that sphere are being celebrated with increasing frequency. The latest of these, the semi-centennial of the typewriter, was recently held in Ilion, N. Y. While several attempts were made before to produce a machine of this character, Christopher Latham Sholes was the first to succeed in making one sufficiently perfected for commercial use. The earliest model built by Sholes with the assistance of Glidden and Soulé was made out of wood. It did write, but in a rather crude way, and the letters were not evenly aligned. Sholes was advised to take this invention to the firm

of E. Remington and Son in Ilion, who at that time were already engaged in the manufacture of small arms and were very unusually experienced in precise manufacturing for those days. They were also one of the few American concerns of half a century ago who maintained a research department. The connection between Sholes and the Remingtons proved a happy one and undoubtedly contributed largely to the success of the machine.

It is comparatively little known (though the story has been published before) that Thomas A. Edison helped in the development of the Sholes typewriter. Some time in the '70's Edison was asked to assist in the development of an automatic telegraph apparatus invented in England and working on the now familiar principle of a perforated tape. In his efforts to produce a device that would print a message directly in letter form instead of in dots and dashes, Edison ran across the Sholes typewriter, which was then available only in the form of a wooden model. An interesting fact illustrating the dependence of inventions on conditions other than mechanical is that while Edison succeeded in perfecting the automatic printing telegraph nearly fifty years ago, it did not come into extended use in this country until quite recently. During the same period, however, the Sholes typewriter has been built by the million and has become a fundamental element in the business life of the country.

It may also be of interest to note the difference between the spread of the typewriter in America and in the British Isles, both English-speaking countries. While its use is universal in all kinds of business and Government institutions on this side of the water, typewritten documents were considered rather informal until quite recently in England. For example, in lawyers' offices mechanical writing did not dislodge the quill until the stress of the war broke down the old tradition.

Cause of Explosion at Bureau of Standards

THE ignition of a mixture of gasoline vapor and air was found to have been the cause of the explosion in the altitude chamber of the Dynamometer Laboratory of the Bureau of Standards at 2 p.m., September 20, 1923. The explosion caused the death of four men and injured six others.

The altitude chamber, in which the explosion occurred, is a small concrete room, the walls and doors of which are designed to stand an external working pressure of about 1500 lb. per sq. ft. and is used for testing motors under the conditions of low air pressure and temperature encountered at high altitudes. At the time of the explosion it was being used for a "winter" test on an automobile engine in connection with a series of tests now being conducted at the Bureau to compare the efficiency of utilization by automobile engines of gasoline of various degrees of volatility. The chamber was closed up tight with no one in it, and the temperature had been lowered to about zero at the time the explosion occurred.

A special Board of Inquiry, headed by Lyman J. Briggs, physicist at the Bureau, made a detailed examination and presented a report in which the following explanation of the disaster was given:

> The explosion was caused by the ignition of a mixture of gasoline vapor and air in the altitude chamber. The Board believes that the presence of the gasoline vapor in the chamber was due either to a leak in the feed line leading to the carburetor of the engine or to a leak from the carburetor due to the sticking of the float mechanism. This conclusion is supported by a remark made by one of the members of the testing staff an instant before the explosion, to the effect that the gasoline readings which he was taking indicated the presence of a leak.
>
> The condition of the set-up following the fire is such that it is not possible to establish which one of the above causes occasioned the leak. Since it is known that only three gallons of gasoline had been drawn for the test, that the engine had been running from about 11 a.m. to 12 noon with the chamber open, that the chamber was closed at about 12:30 for the purpose of running at a lower temperature and that the engine had been operated from about 1 to 2 p.m. with the chamber closed, it is believed that not more than a quart of gasoline could have escaped into the chamber. This amount, however, if vaporized, would have been sufficient to account for the energy of the explosion.
>
> The probable source of the ignition was a backfire through the carburetor. Support to this conclusion is given by the statement of one of the survivors that he heard the engine backfire immediately before the explosion.
>
> The explosion threw out of the chamber a closed apparatus containing about ten gallons of heavy lubricating oil and about five gallons of toluol, breaking the pipe connections and thus releasing part of the contents, which furnished additional fuel for the fire which followed.

The report commended the courage and efficiency with which those on the scene handled the situation and especially the action of C. M. Smith, engineer in charge of the ammonia plant. Mr. Smith, a man of about sixty, was blown out of the door of the building and on to a pile of scrap lumber. His leg was badly bruised, his head cut, and his glasses smashed. Injured though he was, he returned to the wrecked chamber and shut off two ammonia valves, and then went to the refrigerating plant in the basement and operated it to pump the ammonia out of the coils in the wrecked chamber. This action may have prevented further loss of life and the destruction of the entire building by fire.

Results of First International Foundrymen's Congress

OUTSTANDING among the results of the First International Congress of Foundrymen, held in Paris, September 12–15, 1923, and participated in by representatives of eight countries, are (1) the unanimous passage of a resolution recommending international research on testing the quality of iron entering into castings and testing the quality of the castings themselves; (2) the unanimous passage of a resolution recommending the purchase and sale of pig iron on the basis of its analysis; and (3) the formation of a European Malleable Association to deal with technical but not commercial questions.

About thirty American foundrymen attended the congress, which was organized by the Association Technique de Fonderie de France with the coöperation of the Association Technique de Liège (Belgium), the Institute of British Foundrymen, the American Foundrymen's Association, the Association de Fonderie Tchéco-Slovaque, and independent foundrymen of Spain, Italy, and other European countries. Papers prepared by members of these organizations for the congress were presented in both French and English for the most part, and aroused considerable discussion.

An exhibition of foundry machinery and equipment which opened on September 2 continued through the Congress and was visited by a large number of foundrymen. The exhibits included a number of machines built under American patents, shown by French companies, and a few displays of American, British, Belgian, and Italian firms, but the majority were French designs. An educational exhibit of patterns and castings, and molding machines and sand-treating machinery in actual operation, attracted particular attention.

The American delegation spent about two weeks in England before the opening of the Congress as guests of the Institute of British Foundrymen, the National Ironfounding Employers' Federation, and the British Iron and Steel Institute. They were entertained in London, Sheffield, Manchester, and Birmingham, visiting a number of English iron, steel, and non-ferrous foundries, as well as historical and scenic points of interest. At the Hecla works of the Hadfields, Ltd., near Sheffield, where Sir Robert Hadfield was host, and at the adjoining plant of Edgar Allen & Co., the foundrymen were given an opportunity to study British steel-foundry practice, and at Manchester they were conducted through the plant of the Metropolitan-Vickers Electrical Co., Ltd., where over 7000 men are engaged in the manufacture of Westinghouse products.

In Sheffield and in Manchester, before branches of the Institute of British Foundrymen, Dr. Richard Moldenke presented a paper on American Foundry Practice, taking up present tendencies and methods of operation, and led a discussion of cast-iron testing and pig-iron specifications which were later the subject of resolutions at the Paris congress. Before leaving England the party visited the Shipping, Engineering, and Machinery Exhibit at Olympia, London.

In addition to the action taken in regard to testing cast iron, pig-iron specifications, and a European malleable association, the congress was of great importance and value to the foundrymen of all the countries, through their representatives, who became acquainted with European foundry practice both through the papers and discussion at the congress and through the inspection of plants in England and France. A spirit of international coöperation for the advancement of founding methods was evident on all occasions, and great enthusiasm shown for the proposed second conference to be held in this country in 1926.

Detroit Engineers Discuss Municipal Problems

[Mr. Burton's paper on The Fundamentals of City Zoning, which appears in abstract below, was the winner in the Civic Welfare Contest held last spring under the direction of the Associated Technical Societies of Detroit.

One of the objects of this Michigan organization is to increase the interest of the technical man in his city, to inform him about the problems of its growth, and in the solution of these problems to enlist his capacity for decision on a fact basis. The presentation and discussion of municipal problems before meetings of engineers is but the first step toward the ultimate goal of a close alliance between engineers and public affairs. The situation is strongly stated by H. M. Waite, a civil engineer of standing, who, from a four-year period as city manager of Dayton, Ohio, knows whereof he speaks.

"We need the man of practical affairs in public life," says Mr. Waite. "We have too many laws. We cannot enforce what we have. What we need now is readjustment. We need the engineering mind to readjust conditions created through the laws passed by lawyers. We need the practical mind to take the present developed country and apply common sense to its readjustment to conditions as they exist today. Engineers cannot do this by discussing papers. They must take a position in public life.

"The engineer cannot solve this problem alone but he can help. My belief is, that to get the engineer in a helpful mental attitude it is necessary to preach two things to him: First, that the engineer is not a superior being only to be courted from behind his maze of technical education. The engineer must be educated to give, in a practical way, the knowledge which he has. Second, the engineer must be taught that government is a business, and the only way it is possible to get business methods into government is to have the engineer with business judgment enter public life."—EDITOR.]

The Fundamentals of City Zoning

By FRANK BURTON[1]

AMONG the civic problems which have confronted the citizens of growing communities in recent years none perhaps has been the subject of more heated debate, and certainly none has been discussed with less understanding of the fundamental principles involved, than that of zoning. The congregation of many people in small areas, the erection of high buildings, the unforeseen developments in transportation and industry, together with a rapidly rising standard of living conditions and a greater development of the sense of civic responsibilities, have fundamentally altered our ideas of property rights and mutual responsibilities.

It may be that a farmer or miner possessed of land whose value is derived entirely from the products of the soil or the rocks, should be left to an unrestricted use and enjoyment of his land. The value of the city dweller's land, however, is due purely to its relative location with regard to some center of population. Its value is a function of its distance from some important point where persons are accustomed to congregate, and can be measured in terms of the number of people who pass on the adjacent street each day. It is these people who confer upon the property its value. It is because they work and earn money with which they must purchase the necessities and luxuries of life, that this property has acquired a certain value. Is it not absurd to say, then, that those who have so bountifully bestowed a great value where no value would exist without them, may not withhold some of that value if in so doing a great good can be accomplished for all?

Zoning as we now understand it is simply the laying of restrictions on the use of city property by ordinance, such restrictions differing in different zones or areas and having for their object a more equitable distribution of rights and obligations. They may cover the use of land or buildings, the height of buildings, or their size with relation to the lot upon which they are erected.

The good citizen of today, proud of his home, jealous of its surroundings, objects strenuously to the encroachment of industrial and commercial buildings, and in this he receives the sympathy of the great majority of his fellow-citizens. Therefore it requires no argument to convince people that zoning should prohibit commercial and industrial institutions from being established in purely residential neighborhoods.

Students of zoning believe, however, that we should go much further than simply to regulate the conditions surrounding dwelling houses. They point out that the proximity of factories, warehouses, etc., is detrimental to commercial institutions such as retail stores and offices. Certainly it is true that in New York City valuable commercial districts have been greatly damaged and depreciated by the intrusion of sweat shops, the crowds of workers going to and from such establishments having driven away the shoppers that formerly frequented these districts.

However, one of the most harassing problems confronting our City Plan Commission today would be disposed of if that body would abandon its attempt to separate commercial and industrial uses.

Another feature of zoning is that of separating the most objectional industrial uses from the ordinary or non-objectionable uses. Thus iron foundries, slaughter houses, heavy chemical plants, and similar institutions would be kept separate from other factories which do not produce objectionable smoke, odors, or dust. This certainly would be very advantageous to many industries and there is little objection to it as a principle, but in practice the drawing of regulations is very difficult and requires great engineering knowledge. The enforcement of such restrictions will require the greatest study and care in order that justice may be done and that no unreasonable obstacle shall be placed in the path of our city's industrial development.

Beside the restrictions as to use of business property, students of zoning favor limitations as to height and the percentage of lot to be occupied by such buildings. It is generally conceded that in the most congested parts of the city it is unwise to try to legislate regarding the percentage of a lot that may be occupied, but over the question of height there has been a bitter debate.

The opponents to the limitation of height plead high value of real estate and high taxes, but high buildings set close together in congested areas are not good investments and are undesirable from a civic standpoint. It is safe to say that no sound solution of city development can be found until stringent restrictions are imposed on the height of buildings in our congested districts.

No attempt has been made herein to outline the exact terms or form which the zoning ordinance should take, but we might properly review some of the advantages which the advocates of zoning believe will result from a properly prepared ordinance.

Such an ordinance will insure to the property owner a fair and reasonable enjoyment of his investment, by warning him in advance of what may be expected in the way of future development in a given district, and by excluding undesirable buildings which will encroach upon and depreciate the value of his building.

Further, investments will be stabilized and the great economic loss resulting from the premature destruction of buildings will be avoided. It is a common sight to see fine large houses being torn down to make room for mercantile buildings. As a community we know that in the end we must pay for all the good buildings destroyed before the end of their economic life. Commercial enterprises must shoulder the loss and charge it up to capital invested, when in reality nothing is invested.

There are other advantages of zoning not so obvious as those pertaining to buildings. For example, pavements suitable in width and construction for residential districts are unsuitable for industrial districts. Sewer systems, electric-power lines, water mains, street-car lines and other public utilities should be designed with some definite program as to the future development of the district, otherwise they may have to be torn up and replaced at an early date, with a consequent loss to the city at large. In fact, scarcely a branch of city planning can be executed with anything approaching efficiency without some knowledge of what the future will produce. True, zoning alone will not enable us to predict future developments, but it is the best, and in fact the only, step in that direction which we are able to make at this time.

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Engineering and Industrial Standardization

Standards for Cold-Finished Shafting

THE Sectional Committee on the Standardization of Shafting has recently completed a letter ballot on the first of its three reports. This report covers standards for (1) Diameters for Cold-Finished Transmission Shafting, (2) Diameters for Cold-Finished Machinery Shafting, (3) Tolerances on Diameters of Cold-Finished Transmission and Machinery Shafting, and (4) Stock Lengths for Cold-Finished Shafting.

The American Society of Mechanical Engineers is Sponsor for this Sectional Committee, so this report is now before this body for final approval and adoption, after which it will be transmitted to the American Engineering Standards Committee for approval as a "Tentative American Standard." The proposed standards are as follows:

Standard Diameters for Cold-Finished Transmission Shafting shall be: 15/16; 1-3/16; 1-7/16; 1-11/16; 1-15/16; 2-3/16; 2-7/16; 2-15/16; 3-7/16; 3-15/16; 4-7/16; 4-15/16; 5-7/16; and 5-15/16 in.

Standard Diameters for Cold-Finished Machinery Shafting shall be:

Size intervals extending to 2½ in., by sixteenth inches; from 2½ in., to 4 in., inclusive, by eighth inches; from 4 in. to 6 in. by quarter inches.

Standard Tolerances for Diameters of Cold-Finished Transmission and Machinery Shafting shall be:

Diameter	Tolerance
From 0.000 to 1.000 in. (inclusive)	(minus) 0.002 in.
Over 1.000 to 2.000 in. (inclusive)	(minus) 0.003 in.
Over 2.000 to 4.000 in. (inclusive)	(minus) 0.004 in.
Over 4.000 to 6.000 in. (inclusive)	(minus) 0.005 in.

Standard Stock Lengths for Cold-Finished Shafting shall be: 16, 20, and 24 ft.

Czechoslovakia's National Standardization Association the 17th to be Organized

AN INTERESTING account of the organization, functions, and methods of work of the Czechoslovak Standardizing Association was recently printed in *Strojnicky Obzor*, the particulars being obtained from a lecture delivered by Mr. B. Rosenbaum at a technical school in Prague as part of a course on Standardization and Organization. Following are extracts from the summarizing paragraphs of the speaker.

The Czechoslovak Standardizing Association was organized by the metallurgical and metal-working industries. Its program first calls for the standardization of the elements of machines, rules governing the metal-working industry, and gradually the widening of its scope to include other branches of industry. It plans not only to standardize, but also to segregate into types the manufactured articles and parts, and to support every activity tending toward standardization. The Association has started logically by standardizing iron and steel products.

This, of course, involves the standardization of rolled and drawn iron stock and shapes. To accomplish this they invited the coöperation of the smelters and manufacturers of iron and steel not only for metal-working industry, but for industry in general. The manufacture and use of iron concerns all branches of industry, the industrial bureaus of the government, the entire industrial life. It is logical and necessary, therefore, to invite all these interested groups when attempting to establish standards in this field.

The government from the very beginning saw the importance of the Czechoslovak Standardizing Association and supported its organization. The first item of receipts of the C.S.A. was a gift of 10,000 crowns by the Department of Labor. The government delegated representatives of six departments to serve on the Board of Directors. In this way a concord between the plans of the government and of the industries is assured.

All of the largest metal-working establishments are now members of the C.S.A. They not only supply numerically the largest financial support, but they help the standardization activity much more effectively in that they offer for its use all their own factory standardizing experiences and results, and detail from their force specialists to aid in the standardization work of the Association.

The Association employs a sufficiently large permanent staff of experts on which it depends primarily for the effectiveness of the standards work. Standards are not originated by the staff. Their substance and contents are created by the technical representatives of the manufacturers, the consumers, the government, and the scientific institutions. The C.S.A. office staff does, however, prepare the material for the committees, gathering it from both home sources and from foreign countries. It works up the material that has been discussed at meetings and refers this worked-up material to the committees again, and so on, until finally the standard is approved by the committee. The office then arranges it in convenient form for examination by the Board of Directors, upon whose approval it is published so that the general public may have an opportunity to examine and criticize it while in tentative form.

It is apparent that the course of a standard from the beginning to its final acceptance is very long and demands a great amount of work on the part of the headquarters office, both administrative and technical. It is necessary to call the meetings of the various committees and to communicate with the committee members by mail. In many instances it is necessary to keep two or more committees informed concerning the progress of each other's work, so that duplication will be avoided. The more working committees there are, the faster will be the progress of standardization.

In closing, the author says:

Words cannot adequately express the scope of the standardization which should be undertaken. Perhaps the making of a more accurate estimate of the advantages of standardization, when carried on in a national way, for a number of objects whose standardization is very necessary, will show these advantages to be so enormous that the seemingly large expenses connected with the work involved will be infinitesimal in comparison. The standardization activities of the C. S. A. have so far been most generously supported by machine manufacturers who have the most advanced factory standardization. They support the general standardization program though they perhaps need it the least. Apparently their familiarity with purposeful standardization makes them better able to appreciate the importance of general standardization.

Faults and Virtues of Standardization

A RECENT ISSUE of the New York *Times* contained a brief article from the pen of Dr. Charles W. Eliot, President Emeritus of Harvard University, entitled Blight of Standardization. Dr. Eliot introduced his subject with the following paragraph:

A new blight is afflicting education and industries in the United States, particularly the educational part of industries. Its name is standardization, and there is a very general movement to give it application in a great variety of American activities. The blight seems to have started in the industrial domain. To save time, and therefore money, and to increase the productiveness of a given plant, the movements of the individual operative were carefully studied with a view to reduce the number of his movements and changes of posture, and to increase the automatic and repetitive quality of his work. The object was larger production at lower cost, and this object was gained; but the inevitable result was the destruction of the interest of the workman in his work. For the life-long interest of the handworker in the varied products of his skill was substituted the intolerable dullness of tending machinery on a standardized "stop-watch" program.

The article then went on to state that the ideal in education is to develop the utmost possible variety of individual attainment and of group attainment; just as the true goal of democracy is the free development of the utmost variety of capacity in the individual citizen. Dr. Eliot then observed that

It will be for the happiness of the American people to look carefully into the effects of standardization in both the national education and the national industries. It has already gone too far. Although some pecuniary economies can be effected by standardizing processes in both schools and factories, their physical and moral effects are unquestionably bad. As soon as any process in State or Church proves to be injurious to the physical or mental quality of the population a genuine democracy should set to work to modify or suppress it.

Mr. Albert W. Whitney, Chairman of the American Engineering Standards Committee, took exception to the title of Dr. Eliot's article and to some of his statements, and accordingly prepared a reply which was published in the September 2 issue of the New York *Times*. He said in part:

President Eliot's letter describes some of the evil effects of an unwise use of standardization, but in doing so he condemns standardization in general.

Standardization cannot be disposed of so summarily. Like any other powerful instrument, it has its dangers; the problem, however, is not how to get rid of it but how to use it. Standardization can be used safely just as high-tension electricity can be used safely.

As a matter of fact, standardization, which is essentially only the selection and preservation of the best among a mass of the inferior, is at the bottom both of natural evolution and of civilization. Evolution has produced species—standardized types that have proved their fitness to survive. Civilization has produced institutions, and these have been recorded in laws and customs. Both of these processes are essentially standardization, and the extent to which evolution and civilization have gone is measured by such standards.

Mr. Whitney then pointed out that our lives are not only con-

trolled but made possible by standardization. Standardized bodies make possible medicine and surgery. Without some degree of standardization in our mental processes modern education would be impossible. Progress consists primarily in the ability to consign certain standardized actions to the domain of routine, thus setting the mind and the emotions free for fresh adventure and conquest. In the evolution of the mind and body parts of the body have even been set aside as standardization centers, the reflex nervous centers, where standardized actions, namely, habits, are taken care of so that the brain need not be bothered with them. Then speaking principally for engineering and industrial standardization, Mr. Whitney summed up his argument in the two following paragraphs:

I dislike to state anything so obvious, and yet it appears to be necessary, for there is a very general tendency today to confuse the dangers and excesses of standardization with the process itself. As a matter of fact, an overwhelming proportion of the standardization work that is being done today has the highest social value; it is at the very root of the task of making a better and safer and more interesting and generally more worth-while world—safer steel rails and bridges and buildings, better traffic regulation, better health, better opportunities for recreation and education, less poverty, more leisure, more art, more freedom in religion.

The principal dangers in standardization are, first, a too early standardization before the trial stage has been completed; second, a too rigid standardization that does not allow for necessary and ever-present change; third, a too peremptory standardization that is not satisfied to rest the case on innate excellence; fourth, a too ambitious standardization that pushes into fields where it does not belong, particularly the field of essentially emotional and spiritual values. That the problem of getting the good effects of standardization without its bad effects is a serious one no one who is a thoughtful student of standardization would deny; but it's simply one more problem in a world of difficult problems, that's all.

Dr. Eliot replied to Chairman Whitney in a personal letter from which we are permitted to quote the following:

I heartily believe in the great usefulness of the work of the American Engineering Standards Committee, and sympathize in everything you say about what standardization in the proper sense means and does not mean, attempts and does not attempt. When I wrote about the blight of standardization, I had no idea of objecting to such standardization as your Committee labors for and vigorously promotes.

Westinghouse War Memorial Scholarships

FOUR scholarships each carrying an annual payment of five hundred dollars per year are awarded annually by the Westinghouse Electric and Manufacturing Company to employees and sons of employees on the basis of competitive examination, as a Westinghouse War Memorial. Under the plan of awarding four scholarships yearly, four men would be graduated yearly, the total number of scholarships in force at one time being sixteen.

The effort of the company in selecting men for these awards has been to find young men of a many-sided nature. Intelligence, physical qualities, aptitude for engineering work, and ability to shoulder responsibility and to guide their own affairs have been the general points on which the candidates are compared.

The feature of the plan that provides the officials of the company with a means of keeping up the continuity of the personal contact with the men as their college course progresses, is bringing them to the works for the periods of the summer vacations. In this way the men are given the opportunity of securing practical experience as well as of adding to their financial resources. By the time of graduation, the year's work in the shops required of all engineering graduates entering the company's employ has been practically completed.

After graduation, with the exception of one who preferred construction work, all the men have entered the employ of the Westinghouse Company, finding their way into field work in the Service Department, Commercial Engineering, Research Department, Design Departments, etc.

The schools at which Westinghouse War Memorial men have been trained or are now in training include Carnegie Institute of Technology, University of Pittsburgh, University of Cincinnati, Leland Stanford University, University of Pennsylvania, Pennsylvania State College, Cornell University, University of North Carolina, California Institute of Technology, Haverford College, and Ohio State University.

Measurement of Management

(Continued from page 636)

FARQUHAR, HENRY H. Measuring the Performance of the Production Department, *Harvard Business Review*, April, 1923, p. 331.

KNOEPPEL, C. E. Measuring Waste in Industry. *Bulletin of the Taylor Society*, April, 1922.

WILLIAMS, J. H. A Technique for the Chief Executive: A Definite Responsibility—A Definite Procedure—A Definite Measure of Results. *Bulletin of the Taylor Society*, April, 1922.

ROBERT MORRIS ASSOCIATES. Financial Statements: An explanation in brief of a system for their analysis from the standpoint of the credit grantor and of the business executive. The Robert Morris Associates, 1922.

ROE, J. W. The Measurement of Management. Paper before the Society of Industrial Engineers, Detroit, 1922.

DUNN, WILLIAM E. Measuring Executive Ability. *Industrial Management*, May 1, 1922, p. 292.

BENEDICT, H. G. Performance Ratings for Salaried Executives. *Bulletin of the Taylor Society*, August, 1922.

CLARK, WALLACE. The Gantt Chart. Ronald Press Co., N. Y., 1922.

DUNN, WILLIAM E. The Measure of Management. *Bulletin of the Society of Industrial Engineers*, March and April, 1923.

SCHLINK, F. J. The Measurement of Management. *Management and Administration*, August, 1923, p. 173.

BLISS, JAMES H. Financial and Operating Ratios in Management. Ronald Press Co., N. Y., 1923.

Chemical Warfare Service

(Continued from page 646)

containing primer, propelling charge and projectile proper, with its equipment of primer and bursting charge, is dropped in at the open end, and so rapid is the operation of the machine that one shell can be actually fired out of it before the preceding one has reached its target.

One of the great disadvantages of the existing Stokes mortar is its lack of portability. At the same time it is obvious how useful such a machine could be if made portable for rear-guard action, wiping out machine-gun nests, etc. Its usefulness from a military point of view would be enormously increased if it could be adapted for firing Chemical Warfare type shells, for example, shells filled with mustard gas or white phosphorus.

Fig. 5 shows one type of cart that has been devised for the purpose, but several others are under development. In general, it is expected that the means of transportation will consist of a caisson carrying approximately 15 rounds of 4-in. Stokes mortar shell complete with fuses and propelling charges. These caissons will be arranged for either animal or manual traction. To the caisson will be limbered another two-wheeled cart arranged to carry a Stokes mortar complete with baseplate or tools and accessories.

The Chemical Warfare Service is organized as an autonomous part of the War Department. It is working in very close coöperation with the Air Service which realizes the great possibilities that poison gases and smoke screens open to it. It has a special liaison officer attached to it from the Ordnance Department, in addition to which the close proximity of the Aberdeen Proving Grounds to the Edgewood Arsenal insures ease of communication between the two services. The U. S. Navy is also showing a lively interest in the work of the Chemical Warfare Service, frankly realizing the consequences that might be the result of an attack by poison gas on an unprotected ship and the advantages of smoke screens and similar devices.

While the most important features of the work of the Chemical Warfare Service for obvious reasons cannot, and indeed should not, be described, it is believed that enough has been said to indicate the general character of this work and to show that as far as possible everything is being done to insure proper protection for the American soldier against the new forms of attack, and that our Army has the ability to hold its own in this field whenever it may be called upon to do so.

LIBRARY NOTES AND BOOK REVIEWS

COST CONTROL FOR FOUNDRIES. By Frank Everitt and Johnson Heywood. McGraw-Hill Book Co., New York, 1923. Cloth, 6 × 9 in., 226 pp., illus., $3.

A detailed description of the theory, practice and routine of cost accounting for foundries, presented in a way that can be easily understood by foundrymen with no claim to accounting knowledge. The method described is planned to be simple and inexpensive, yet accurate. It is fully set forth, and a complete set of the necessary forms is given. The method is applicable to foundries of varying kinds and sizes.

DIE DAMPFTURBINEN, Vol. 2. By Const. Zietemann. Walter de Gruyter & Co., Berlin and Leipzig, 1923. Boards, 4 × 6 in., 141 pp., illus., $0.25.

This, the second volume of this little handbook, discusses in its first section the thermal calculations the selection of the size or number of stages and the determination of the blade velocity. Two worked-out examples are given, showing how the methods are used. Sections two and three deal with the design and construction of the moving and the stationary parts of turbines. The treatment is extremely concise, but thoroughly practical.

DAVISON'S TEXTILE "BLUE BOOK," 1923–24. Davison's Publishing Co., New York, 1923. Cloth, 7 × 9 in., 1729 pp., maps, $7.50.

The "Blue Book" is a comprehensive directory of American firms engaged in the textile industries as manufacturers, dyers, bleachers, brokers, commission merchants, or dealers in raw or waste materials. The information on mills includes the location, capacity, number of employees, officials, capitalization, etc. The directory is classified by products and by location, and a name index is provided. A directory of supply dealers is included.

DICTIONARY OF APPLIED PHYSICS, Vol. 5: Aeronautics; Metallurgy; General Index. By Sir Richard Glazebrook. Macmillan & Co., London, 1923. Cloth, 6 × 9 in., 592 pp., illus., diagrams, tables, 63s.

The concluding volume of this valuable work of reference is divided in two parts, treating of aeronautics and metallurgy, respectively. Part one contains long articles on Full-Scale Aerodynamical Research, by R. M. K. Wood; Experimental Tests of Strength of Aeroplane Structures, by W. D. Douglas; Theory of Aeroplane Structures, by W. L. Cowley; Doping and Fabrics, by Guy Barr; Performance and Stability of Aircraft, by Leonard Barstow; Airscrews and Helicopters, by Arthur Fage; Experiments on Airships, by J. R. Pannell and R. Jones; Diffusion through Membranes, by Guy Barr; Engines, by G. H. Norman; Model Experiments, by E. F. Relf and H. B. Irving; and Hydrodynamical Theory, by Hermann Glauert.

Among the longer articles in part two are: Typical Alloy Systems, the Equilibrium Diagram and the Relationship of Structure and Physical Constants, by J. L. Haughton; Special Alloys and Aluminium Alloys, by Walter Rosenhain; Aluminium, by Donald Finlayson; Electric Furnaces, by F. A. J. FitzGerald; Laboratory Furnaces, and Refractories, by E. A. Coad-Pryor; Invar and Elinvar, by C. E. Guillaume; Iron-Carbon Alloys, and Defects and Failures of Metals, by D. Hanson; Relations of Strain and Structure, Thermal Study and Thermal and Mechanical Treatment, by Walter Rosenhain; Aggregation and Flow of Solids, by W. D. Haigh; and Special Steels, by W. H. Hatfield. An index to the volume and a general index to the whole work are included.

ELECTRICAL VIBRATION INSTRUMENTS. By A. E. Kennelly. Macmillan Co., New York, 1923. (Engineering Science Series.) Cloth, 6 × 9 in., 450 pp., illus., diagrams, tables, $6.50.

Dr. Kennelly's book presents, from an electrical engineering viewpoint, the characteristics of telephone receivers, and of other vibrational instruments, as reciprocating electric motors. It is based on researches carried on at the Massachusetts Institute of Technology and at Harvard University during the past fourteen years. The book is intended as a textbook for students of telephone engineering, and also as a reference book on the receiver for telephone engineers.

ELEMENTARY THERMODYNAMICS OF AUTOMOBILE ENGINES. By Erwin H. Hamilton. McGraw-Hill Book Co., New York, 1923. Cloth, 6 × 9 in., 287 pp., illus., tables, $3.

This book presents the fundamental principles of the thermodynamics of internal-combustion engines, as used in automobiles, with sufficient detail to illustrate them properly. It is intended as a textbook for college students and as an advanced text for trade schools.

ELEMENTS OF RADIO COMMUNICATION. By Ellery W. Stone. Second edition. D. Van Nostrand Co., New York, 1923. Cloth, 5 × 8 in., 318 pp., illus., diagrams, $2.50.

Prepared originally for radio students in the Communication Service of the Navy, this book has proved suitable for use in other schools and for self instruction. The subject is presented physically rather than mathematically, in a manner requiring but little previous knowledge on the part of the reader. This edition has been thoroughly revised and enlarged by the addition of recent developments.

ESTIMATING BUILDING COSTS. By Charles F. Dingman. McGraw-Hill Book Co., New York and London, 1923. Fabrikoid, 4 × 7 in., 240 pp., tables, $2.50.

In preparing this volume, Mr. Dingman has had in mind the needs of the young man in the building business who wishes to become an estimator. Particular attention is given to the exposition of principles and to methods, so that the reader will be trained to analyze construction jobs into their components, to apply his cost data, adjusted to the conditions, to the necessary operations, and thus to calculate the cost of doing the work.

FACTORY MANAGEMENT WASTES AND HOW TO PREVENT THEM. By James F. Whiteford. D. Van Nostrand Co., New York, 1920. Cloth, 6 × 9 in., 220 pp., charts, $4.

Of the work of the average factory, about one-fifth deals with the processing and treatment of materials, and this in usually efficiently done in a well-organized way. The remaining four-fifths of the work, dealing with the common things, done day after day by routine, is seldom well organized. It is here that the greatest wastes are to be found. It is the purpose of this book to discuss these wastes, their causes, detection and remedies. Removal of them will, the author believes, remove some of the prevalent difficulties between employer and employed, manager and managed. The subjects discussed include works organization and management, production control, machinery, performance records, overtime, cost finding, wages and profit sharing.

FOREST RESOURCES OF THE WORLD. By Raphael Zon and William N. Sparhawk. First edition. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 9 in., 2 vols., maps, tables, $12.

An inventory of forest resources in all countries. In order to make it possible to compare different countries, an attempt has been made in every case to show the forest area, annual growth and annual cut, and to make deductions from these factors as to the forest resources of the different countries. The topics discussed for each land are: forest area; character and distribution of forest; character of ownership; annual growth; annual cut; exports and imports; domestic consumption; progress in forest conservation; and the probable future. A mass of useful information, hitherto widely scattered, is brought together and conveniently summarized. References to sources of information are included.

DIE LINIENFÜHRUNG DER EISENBAHNEN. By H. Wegele. Edition 2. Walter de Gruyter & Co., Berlin and Leipzig, 1923. Boards, 4 × 6 in., 110 pp., illus., diagrams, tables, $0.25.

A very brief summary of the principles of railroad location and construction, revised to meet present conditions. Discusses the problems of an economic and a technical nature that arise, the principles that govern transportation, and the governmental regulations for railroad construction and operation in Germany. A convenient reference book.

PATENTS THROUGHOUT THE WORLD. By William W. White and Wallace White. Trade Mark Law Publishing Co., New York, 1923. Cloth, 6 × 9 in., 244 pp., maps, tables, $7.50.

In this digest of the patent laws of the different countries, a uniform arrangement of the data under the same headings has been adopted for each country. Ready reference is further facilitated by a chapter of general information on foreign countries and by a series of tables which show at a glance the conditions under which patents may be obtained from the various governments. The book will be useful to inventors and patent attorneys.

PHASE RULE AND ITS APPLICATIONS. By Alexander Findlay. Fifth edition. Longmans, Green & Co., New York and London, 1923. Cloth, 6 × 9 in., 298 pp., illus., diagrams, tables, $3.50.

The object of the author is to give a non-mathematical exposition of the phase rule and its applications which will explain the principles underlying it and illustrate its use. The book is intended as an introduction to the subject for students of chemistry and also as a textbook for students of metallurgy and geology.

The advances in the subject which have occurred since the appearance of the fourth edition, in 1914, have necessitated the complete revision and rewriting of certain sections and the addition of much new matter.

PRACTICAL HEAT. By Terrell Croft. McGraw-Hill Book Co., New York and London, 1923. Cloth, 6 × 8 in., 713 pp., illus., tables, $5.

Practical Heat is intended to present the subject of heat and its practical applications in a manner that may be followed by persons with limited mathematical attainments. The text begins with the consideration of the fundamental concepts of physics, force, pressure, work, energy, and power. Next follows a discussion of heat, its source and its relation to matter. This is followed by the measurement and transformations of heat, where the first and second laws of thermodynamics and the fundamental equation of heat transference are explained. The effects of heat, expansion, heat phenomena of gases, etc., are next considered.

Succeeding chapters discuss gas and vapor cycles, fuels, combustion, power plants, heating, refrigeration and measuring instruments, attention being directed to the demonstration of the way in which theoretical principles are applied in engineering practice.

RAILROAD ELECTRIFICATION AND THE ELECTRIC LOCOMOTIVE. By Arthur J. Manson. Simmons-Boardman Publishing Co., New York, 1923. Cloth, 6 × 9 in., 332 pp., illus., diagrams, tables, $4.

A book written to give railway officials and operating men a knowledge of the design, construction and operation of electric locomotives and of their application to different kinds of railroad service. The book opens with a statement of theoretical principles, which is followed by descriptions of the various motors and other elements of the electric locomotive, illustrated by examples from practice. Examples of the solution of problems encountered in electrification are given. An appendix contains a brief history of the electrification of American steam railroads and a number of useful tables covering electrification projects throughout the world.

RAILROADS, RATES, SERVICE, MANAGEMENT. By Homer B. Vanderblue and Kenneth F. Burgess. Macmillan Co., New York, 1923. Cloth, 6 × 9 in., 488 pp., $4.50.

The authors of this book, professor of business economics at Harvard University and general attorney of the C. B. & Q. R. R. Co., respectively, have written it to give information concerning the elaborate system of governmental machinery by which railroad regulation is accomplished in the United States. The book is intended for those with an interest in the methods of regulation, for students of railroad practice, and for railroad officers. It is neither a law book nor a text on economics, but is rather a volume presenting the observations that have resulted from experience in teaching the subject and in active practice before courts.

ROBERT FULTON AND THE SUBMARINE. By Wm. B. Parsons. Columbia University Press, New York, 1922. Cloth 7 × 10 in., 154 pp., illus. portraits, $4.

An interesting record of Fulton's submarine boats, of his experiments in France and England, and of his unsuccessful attempts to interest the governments of those countries in his invention. Much of the material is here published for the first time and is taken from recently discovered descriptions written by Fulton himself.

SCIENTIFIC MANAGEMENT AND THE ENGINEERING SITUATION. By Sir William Ashley. Humphrey-Milford, Oxford University Press, London, 1922. (Barnett House Papers, no. 7.) Paper, 6 × 9 in., 28 pp., $0.35.

This pamphlet contains the Sidney Ball Memorial Lecture delivered before the University of Oxford, 28 October, 1922, by the Vice-Principal of the University of Birmingham, Sir William Ashley, who devotes himself to criticism of scientific management, particularly as applied to engineering and the metal trades. His examination is analytical and his attention is particularly directed toward the method of remuneration of labor. He finds much to criticise unfavorably from the viewpoint of the student of economics, in present theories of management, and indicates his objections briefly in an interesting way.

SPECIAL STEELS. By Thomas H. Burnham. Isaac Pitman & Sons, London, 1923. (Pitman's technical primers.) Cloth, 4 × 6 in., 194 pp. illus., diagrams, tables, $1.70.

The author of this book endeavors to meet the need for some work from which the student or user of special steels can obtain a concise technical survey of the nature and scope of this branch of metallurgy.

After a general introduction and description of the constitution and manufacture of special steels, the important steels are described, special consideration being given to their working, heat treatment and uses. Appendices give bibliographic references for those desirous of further information.

STROME UND SPANNUNGEN IN STARKSTROMNETZEN ALS GRUNDLAGE ELEKTRISCHER LEITUNGSBERECHNUNGEN. By Josef Herzog, and Clarence Feldmann. Walter de Gruyter & Co., Berlin and Leipzig, 1923. Boards, 4 × 6 in., 110 pp., diagrams, tables, $0.25.

A concise presentation of the theoretical considerations in the design of distributing systems for electric power. The little volume is intended as a vade mecum for the engineer, not as a textbook for the student. The methods for calculating distributing networks are set forth explicitly, in spite of the briefness of the text.

THÉORIE DES SURFACES PORTANTES; LA THÉORIE DE PRANDTL. By Maurice Roy. Gauthier-Villars et Cie., Paris, 1922. Paper, 5 × 8 in., 131 pp., diagrams, 12 fr.

An attempt to present in a simple manner the basis of the theory of supporting surfaces elaborated in Germany by L. Prandtl in the aerodynamic laboratory at Göttingen, and to present the results obtained up to the present time. Part one sets forth the fundamental idea of the theory and includes a study of two interesting problems raised by Joukowski's theory. The second part describes the applications of a simplified form of the theory, presented by Professor Prandtl before the Göttingen Scientific Society, in the design of wing surfaces and propellers.

VORLESUNGEN UBER INGENIEUR-WISSENSCHAFTEN; PART 2, EISENBRUCKENBAU, Vol. 3. By Georg Christoph Mehrtens. Wilhelm Engelmann, Leipzig, 1923. Paper, 7 × 10 in., 445 pp., illus., diagrams, tables, $5.10.

This, the concluding volume of Professor Mehrtens' lectures on steel bridges, is divided into four sections. Section one treats of girder systems and their calculation. Section two discusses the structural details of truss bridges of various kinds, while section three is upon the details of suspension bridges. The final section describes the fabrication and erection of bridges, and includes accounts of the erection of the Manhattan, Queensboro, and Hell Gate bridges. The volume is very fully illustrated.

DIE WALZWERKE, EINRICHTUNG UND BETRIEB. By A. Holverscheid. Walter de Gruyter & Co., Berlin and Leipzig, 1923. Boards, 4 × 6 in., 144 pp., illus., diagrams, $0.25.

This little work describes modern rolling-mill machinery and practice. Mills for structural iron, sheets, wire and pipe are described, as well as a number of mills for special purposes. An appendix on heating furnaces is included. The treatment is condensed, but covers the essentials.